Vol. XIX. No. 9 Whole No. 164

DECEMBER, 1919

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

School Science and Mathematics

Vol. XIX, No. 9 December, 1919 Whole No. 164

SOME SUGGESTIONS FOR A GENERAL SCIENCE COURSE.

By Elizabeth Bayer,

Wm. Penn High School for Girls, Philadelphia, Pa.

By this time the pros and cons of a general science course have become pretty much of a bore. General science is here, and whether we approve or not, it seems to be here to stay, for a while at least, judging from the many text books on the subject, and the increasing number of schools, both night and day, that are introducing it in their curricula. There has recently been started a general science monthly which is added evidence of faith and enthusiasm for its future.

How this newcomer into the high school world received its name and just who it is, is not clear. Its surname at least indicates distinguished ancestry (in many quarters this legitimacy is questioned) but its other name is uncertain and such ones as "Special," "First Year," "Introduction to," "Vocational," "Junior," etc., are still under consideration, although the infant has long outgrown its baptismal clothes.

A glance at the table of contents of any of the current texts in general science shows in the main two distinct plans followed, viz.: (a) physical geography as a basis and (b) an outline combining physics, chemistry and biology. The physical geography scheme is evident by such chapter headings as "The Earth," "The Earth's Crust," "The Atmosphere of the Earth," "Life on the Earth," "The Sea," "Volcanoes," etc., while the Physics-Chemistry-Biology Outline is shown by chapters on "Matter," "Fire and Energy," "Heat," "Water," "Carbon," "Magnets and Electricity," "Light and Sound," "Simple Machines," "Acids and Alkalies," "Plants," "Animals." There are in addition some texts that show a combination of these two plans for grouping such simple experiments as are considered necessary for explaining to the boys and girls of today something of

their environment and their relation to that environment.

If we review elementary geography texts we see similar characteristics. The older texts emphasized the physical and political features of geography, but the newer ones are omitting these somewhat and laying most stress on the commercial and industrial phases. One series of such geography texts gives us the titles, "How the World is Clothed," "How the World is Fed," and "How the World is Housed." This food-shelter-clothing classification is brief and simple, yet the plan is broad enough to be adapted to local conditions or preferences and it also permits wide scope for omitting certain subjects that in other schemes are included for the sake of consistency, for example, the study of glaciers, volcanoes and other physical geography subjects that are far removed from both present and future interests and experiences of the average school children.

At present an effort is being made in the John Wanamaker school, Philadelphia, to give its employees certain commercial and industrial geography information which is not now available, and which seems necessary for adequate instruction. This demand seems to be (1) a knowledge of the source and production of the raw materials making up the merchandise of a great department store, (2) the preparation and manufacture of this raw material into the finished article of merchandise and (3) any specific or general information regarding the merchandise that is of interest and value to both buyer and seller.

In many current texts (1) and (2) are being handled in a broad and general way, leaving detailed discussion for supplementary books. The third, however, "information of value and interest to both buyer and seller," needs special comment. Here the information is varied and miscellaneous; the material is scattered in histories, particularly those of arts and crafts objects, or buried in trade journals—all sources more or less removed.

Some such information would explain the origin of the names of some of our commonest fabrics; serge, from the Spanish Xerge, meaning to protect from rain; long cloth, so named because first used for infants' long clothes; gingham, from Ginghamp, a town in Brittany, where it was first manufactured; likewise calico from Calicut India, where made, and madras from Madras, India, where it was originally woven for sailors' headdress; and more recently in our own day, mercerized cotton from John Mercer, who first used the caustic soda process. It might

be valuable, for instance, in buying carpets and rugs, to know something of the meaning of such terms as "Axminister," "Wilton," "ingrain," etc., or if purchasing groceries, to have a knowledge of "Mocha," "Java," "Rio," "Astor Blanks," and the like. It might at times save us several coppers on the pound, and a few dollars in the year.

If texts such as Wanamaker might use were available, would they not be a development of the food-shelter-clothing plan? For what does the great department store of today exist but to supply these three great necessities which keep the world a-moving? Economists tell us (most of us know without being told) that this trio takes at least 50 per cent of the average income. The plan, therefore, seems to be not only broad and elastic, but quite fundamental and economic.

The following outline attempts in a general way to arrange and to group experiments into projects according to this scheme. All of the experiments are simple enough to be used for the eighth or ninth grades, for the various vocational, pre-vocational, and continuation school programs. None of them are long enough to require the conventional double laboratory period, which often offers difficulty in school organizations during these grades. It might be suggested too that parts of this outline relating to foods and shelter would explain and give interest to cooking classes or the section on clothing might very well supplement and reenforce dressmaking classes.

A—Foods Projects.

I. Food tests.
1. To test foods for starch
2. To test foods for sugar.
3. To test foods for protein.
4. To test foods for fat.
5. To test foods for mineral.
6. To see what foods are present in milk.
7. To find the characteristics of acids; to test for them in foods.
8. To find the characteristics of bases.
9. To see what table salt is.

II. Cooking foods.
1. How should meats, eggs and milk be properly cooked?
2. How does cooking affect cereals and starchy foods?
3. How is baking soda used in baking?
4. How is yeast used in baking?

III. Care of foods.
1. Why should bread and cheese be kept in dry cans?
2. How do molds grow?
3. Do bacteria thrive as readily in dry as in moist foods?
4. How does temperature influence the growth of bacteria?
5. Are bacteria in dust, in water, and on the fingers?

IV. Adulteration of foods.
1. How is tea adulterated; coffee adulterated?
2. Two ways to tell fresh eggs.

3. To test butter for oleomargarine.
4. To test candy syrups, cake icings, for glucose.
5. To test home milk for the amount of fat or cream present.

V. Water.
1. How does distillation affect dirty, salty water?
2. What do we mean by "hard water"?
3. How does filtration of the town water purify it?
4. To test my home drinking water.

B—Clothing Projects.

I. Fibre test.
1. What are some characteristics of cotton and linen fibres?
2. What are some characteristics of silk fibres?
3. What are some characteristics of wool fibres?

II. Adulteration of fabrics.
1. To test "all wool" underwear for cotton.
2. To test cheap silk stockings.
3. To test linen handkerchiefs, towels, tablecloths for cotton.

III. Dyeing of materials.
1. To see what fibres dye best in picric acid.
2. Do mordants make some fibres dye better?
3. How is variety of color obtained in dyeing?

IV. Laundry and cleaning of materials.
1. How is muslin bleached commercially?
2. What causes rust spots on clothes which have no hooks nor eyes?
3. To remove various stains from different materials.
4. To clean gloves by the "dry cleaning" method.
5. To see how soap and water method of laundry removes dirt from clothes.
6. To make soap from kitchen grease.

C—Shelter Projects.

I. Weather.
1. To see how a thermometer is marked to record temperature.
2. To make a graph of a week's temperature.
3. Why is it cooler after sprinkling the streets?
4. How does a barometer forecast weather?
5. A weather map.

II. Ventilation.
1. Oxygen and its effect on combustion.
2. To make carbon dioxide and to learn its properties.
3. Is a draft necessary for combustion?

III. Heat in the home.
1. How is a house heated by hot water?
2. How is a house heated by hot air?
3. How can gas for cooking be made from soft coal?
4. How does a fireless cooker work?

IV. Light in the home.
1. What is the difference between the flame of a gas stove and that of gas light?
2. Does a mantle burner consume less gas than a plain burner?
3. Where should lamps and lighting fixtures be placed for reading?
4. How is the acetylene bicycle lamp made?
5. How is the little pocket flashlight made?

V. Boy-scout or camping equipment.
1. How is my compass a correct guide? (Telegraph and doorbell?)
2. To understand how a fire can be started with a lens.
3. To understand how to use my camera intelligently.
4. To see how films "take" a picture.

VI. Tools in common use.
1. How does a wheelbarrow lighten a heavy load?

2. What is the advantage in using skids for unloading boxes?
3. How can a pulley easily lift a piano to the upper story?
4. How is a man able to jack up an auto weighing several tons?

VII. Useful minerals and metals.
1. What are the characteristics of some important minerals?
2. What are the characteristics of some important building stones?
3. What are the characteristics of copper and aluminum?
4. How can copper, aluminum, nickel, zinc, and silver objects be cleaned?
5. How can silverware be readily cleaned?
6. How are spoons silverplated?

A minor consideration here seems pertinent. In such a course, as outlined, provision should be made for trips to museums to inspect products there, and for excursions through local industries to observe, at first hand, the many processes necessary to make the simplest articles of our existence. Since troops of live wire, curious school children are not conducive to the present day regime of scientific management in industry, these personally conducted tours are seldom obtainable. In lieu of these the Department of Public Instruction at Washington provides free, except for transportation charge, slides and motion pictures, covering a wide range of subjects—commerce, industry, and social work. In addition, however, would not exhibits from local industries give much needed and immediate information regarding the industrial geography of the children's home town or city? In large cities it might be difficult to get exhibits from manufacturing concerns because there would be such a large number of schools to supply, but in smaller towns and cities this might not be so. Indeed, in many cases contributors would feel a local pride in being represented and studied in the schools. Certainly a visitor to a school in a strange community would find more to interest him in an exhibit of local industries and activities than he now finds in the usual array of Corots and Michael Angelos that he passes with a glance.

Our attempt, then, is to learn something of these three prime necessities of our existence—food, shelter and clothing—by means of simple laboratory experiments, and by a study of the commonest merchandise from raw material to the finished product, with special emphasis on local industries. All this may be a grand shake-up, as general science has been facetiously called, but it may also mean good sense, another term similarly applied to general science. Now if good sense regarding 50 per cent of the family budget means real economy, and an increased buying power of money, then certainly good sense is worth while for the vast majority of school children today.

Besides this good sense, are not the children trained, if proper methods are used, in careful observation, exact statement and logical thinking—the traditional virtues of the traditional sciences. Furthermore, as we know all too well, the school mortality is very high during these eighth and ninth grades, and experience has proved to me and my colleagues that this is the *only* type of science instruction which these children will accept. From such a course these children will have some idea and appreciation of the tremendous importance of science in modern industry and progress and they will see how definite knowledge and experiment have replaced superstition and guess work, and have set up standards in modern living conditions unknown a generation ago. They will at least get a glimpse of this marvelous and wonderful world in which we live—most of us with eyes that see not, and ears that hear not.

THE PSYCHOLOGY OF YOUTH.

"If 1 pound, lifted 1 foot, represents 1 foot-pound of work, then I should think that 250 pounds, lifted 250 feet, would represent 250 foot-pounds of work."

The limit of action of a lift-pump is the top of the pump.

A lift-pump is used to raise water out of a hole or well where it is not wanted.

The force-pump is just the opposite of the lift-pump.

ANDREW CARNEGIE WAS AN EARNEST SUPPORTER OF METRIC UNITS.

The passing of Andrew Carnegie brings to mind the fact that he had been for years an ardent advocate of world standardization in weights and measures through the adoption of metric units.

Andrew Carnegie was a member of the Metric Committee of the National American Association of Manufacturers, which strongly urged metric standardization. At the time the committee met, he made the following statement:

"The metric system of weights and measures is one of the steps forward that the Anglo-Saxon race is bound to take sooner or later. Our present weights and measures, inherited from Britain, are unworthy an intelligent nation today. The advantage America possesses over Britain in the decimal dollar system as compared with their pounds, shillings, and pence, would be fully equalled by the adoption of a metric system of weights and measures."

Carnegie believed that world standardization of weights and measures would aid greatly not only the cause of world trade, but also that of world peace. On another occasion he said: "The old weights and measures are a discredit to us. We shall inevitably adopt meter-liter-gram, if for no other reason than as an aid to peace; but they would enormously aid our world trade."

EXPERIMENTAL AND ECOLOGICAL STUDY OF FOUR SPECIES OF ACRIDIDAE (GRASSHOPPERS)[1].

By Harry L. Andrews,

Northeast High School, Kansas City, Mo.

I. Introduction.

The material here presented is based on field observations and laboratory study of four species of Acrididae. In an attempt to make a census of the animal population of a plot of ground, my attention was called to the predominance of Orthopteran life. Field observations revealed not only variety in species and predominance in number of individuals of this order, but also a tendency towards segregation of species into associations.

Many attempts have been made in connection with taxonomic papers to list Orthoptera according to the vegetation upon which they are found, and to explain their distribution as due to the distribution of their food plants. It is the purpose of this paper to call attention to some environmental relations of greater ecological importance than food, thus accounting for the formation of associations in terms of behavior. I wish to express my thanks to Dr. V. E. Shelford for helpful suggestions and assistance while the work was in process.

II. Localities Studied.

The area studied is located one mile north of Urbana, Illinois, along a drainage ditch. The soil is clay, having been placed there in the digging of the ditch. Four distinct stations were studied.

First, the brook margin or narrow strip of land bordering the brook supported a luxuriant growth of willows, smart-weed, cockle-burrs and water-grass.

[1]Contribution from the Zoological Laboratory of the University of Illinois, No. 143.

Second, the clay bank consisted of a steep slope at the base of which was a regular incline adjoining the brook margin. The vegetation was mainly wild lettuce, rag-weed, and white clover.

Third, the top of the bluff or sweet clover association was almost level. On the ground stratum was largely blue grass supporting a rank upper growth of sweet clover, wild lettuce, burdocks and thistles.

Fourth, farther down at a turn in the stream was a temporary marsh, exposed only at low water, and hence supporting little vegetation.

1. Brook Margin Association.

Each region had its predominating species. On the brook margin were nymphs of all sizes and adults of *Melanoplus differentialis Thos.* Besides *M. differentialis* were a few of the following species: *M. bivittatus Say,* forked tailed katydids (Scudderia furcata Bruner), short horned locusts (Orphuella speciosa Scud), and the slender meadow grasshopper (Xiphidium fasciatum DeG.). The dense growth and moist ground formed a cool habitat. *M. differentialis* were in very large numbers. Only a small number of the above named varieties were found, while adults and nymphs of *M. differentialis* were on every stem. The nymphs were on the ground stratum and flat leaf surfaces, while the adults were perched on the largest stems.

2. Clay Bank Association.

The clay bank had its distinctive population. *Dissosteira carolina Linn,* predominated. A few locusts (Psinidia fenestralis Serv) were found in this habitat.

3. Sweet Clover Association.

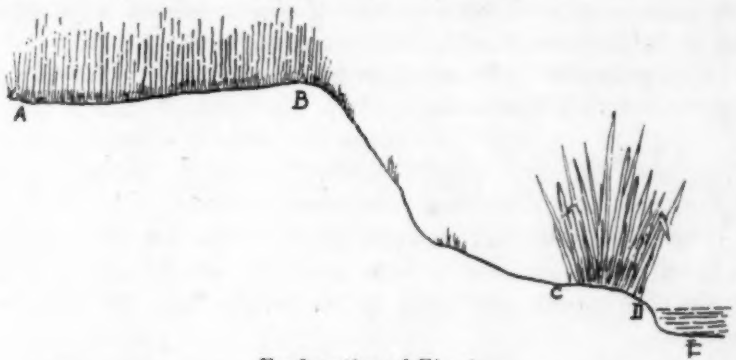
In the sweet clover association nymphs and adults of *Melanoplus femur rubrum DeG.* were in excess. A sweep of the net would capture a small number of forked tailed katydids (Scudderia furcata Bruner) and a few meadow grasshoppers (Xiphidium strictum Scud). The nymphs of *M. femur rubrum* were found on the ground and lower strata in great numbers. Medium sized nymphs took positions on the broad leaves of the burdock and thistles. The adults were usually on the stems of the sweet clover plants.

4. Temporary Marsh Association.

On the temporary marsh were found many *Tetrix granulata.* They were found on the ground stratum.

The observation that certain species of insects are commonly

found in the same associations as certain plants does not justify the conclusion that the insects are there because they feed upon the plants. Looking into the habitat, we find nymphs and adults choosing different strata, different positions, and different food plants. Such observations have led to experimental work in order to interpret the relation of animals in their normal environments in terms of their physiological constitutions.



Explanation of Fig. 1.

A–B Sweet Clover Association. B–C Clay Bank. C–D Stream Margin. E Marsh.

IV. Experimental Results.

1. *Reactions to Light.*

A number of experiments were carried on in the field and laboratory in studying light and its effects. The apparatus used has been described by Shelford.[1] It consists of pans 10x30 centimeters at the bottom and slightly larger at the top and about 7 centimeters deep, painted black. Glass tubes about 4 1-2 centimeters in diameter with hemispherical ends and caps making the tube 30 centimeters long were used for containers. One-third of the inside circumference which is placed downward is painted black. A cover with an adjustable slit was used to allow bright light, medium light, and shade divisions to strike the container.

The stock used in the experiments was usually collected in the morning and experiments run in the afternoon. At times, in which collecting was not practical, stock kept in cages not longer than twenty-four hours was used. Five or ten grasshoppers were used in the experiments. Readings were recorded every five minutes until twenty had been taken. In cases where data did not seem conclusive, five experiments were run and

[1]School Science and Mathematics, May, 1917, page 400.

averages made. In other cases only the most representative data are given.

Experiments in phototaxis show that grasshoppers do not exhibit the same responses. One species may respond in one way, another in another manner. Nymphs may react very differently from the adults of the same species. In tests with adults of *Melanoplus femur rubrum*, *Dissosteira carolina*, and *Melanoplus differentialis*, *D. carolina* and *M. femur rubrum* were positive to light, while *M. differentialis* was negative.

(Percentages are averages from twenty readings, each reading recorded every five minutes.)

Adults *D. carolina.*		Adults *M. femur rubrum.*		Adults *M. differentalis.*	
Light.	Dark.	Light.	Dark.	Light.	Dark.
69%	31%	66%	34%	32%	68%

It is noticeable that nymphs of *M. femur rubrum* and *D. carolina* do not respond to light as do the adults, but in both species the adults are found to be positive and the nymphs negative.

Adults *M. femur rubrum.*		Nymphs of *M. femur rubrum.*	
Light.	Dark.	Light.	Dark.
66%	34%	38%	62%
Adult *D. carolina.*		Nymphs of *D. carolina.*	
Light.	Dark.	Light.	Dark.
72%	28%	40%	60%

It is significant that the difference in reaction between the nymphs and the adults of these two species corresponds with the difference in light conditions in the localities in which the two stages are found. Thus the adults of *M. femur rubrum* were usually exposed to the light on the tops of the stalks of sweet clover, while the nymphs were on the under sides of the leaves of plants of the low strata or among the grasses. Similarly, the adults of *D. carolina* were found on bare clay banks exposed to the direct rays of the sun, while the nymphs were invariably found in the partially protected places formed by sparse growth of clover, rag-weed, and similar vegetation near the foot of the clay bank.

In contrast to the above two species, the nymphs and adults of *M. differentialis* are alike in their response to light, both being negative.

Adult *M. differentialis.*		Nymphs of *M. differentialis.*	
Light.	Dark.	Light.	Dark.
42%	58%	30%	70%

Here again the response under experimental conditions is what would be expected from the character of their habitat, for

both nymphs and adults are confined to conditions of moisture and shade.

(a) Intensity and Direction.—Experiments to show reactions to intensity and direction of light were performed in the dark room of the Vivarium at the University of Illinois with the Yerkes light grader. The apparatus was essentially the apparatus described by Mast ('11, p. 61) and Shelford ('14, p. 310) with a few modifications. A 120 watt Nernst lamp was used. The triangular opening on the lens had a base of 120 mm. and an altitude of 90 mm. The distance from the glower to the stage was 80 centimeters. A heat screen of distilled water was placed between the lens and the gradient box.

It was found in some cases that nymphs and adults react alike, while in other species the reactions were reversed. The number of grasshoppers used and the readings taken were the same as in former light experiments.

Melanoplus femur rubrum.	Direction.		Intensity.	
	Light.	Dark.	Light.	Dark.
Very small nymphs	40%	60%	42%	58%
Second and third stage	34%	66%	40%	60%
Last stage	72%	28%	76%	24%
Adults	64%	36%	62%	38%

Small nymphs of *M. femur rubrum* are negative to direction and intensity. Adults are positive to direction and intensity.

Melanoplus differentialis.	Direction.		Intensity.	
	Light.	Dark.	Light.	Dark.
Very small nymphs	44%	56%	24%	76%
Second and third stage	38%	62%	28%	72%
Last stage	34%	66%	48%	52%
Adults	32%	68%	48%	52%

Nymphs and adults of *M. differentialis* are negative to direction and intensity. Adults are less negative to direction, nymphs are less negative to intensity.

Dissosteira carolina.	Direction.		Intensity.	
	Light.	Dark.	Light.	Dark.
Nymphs	88%	12%	76%	24%
Adults	64%	36%	66%	34%

Both nymphs and adults of *D. carolina* are strongly positive to both intensity and direction.

Tetrix granulata	Direction.		Intensity.	
	Light.	Dark.	Light.	Dark.
Adults	51%	49%	25%	75%

Tetrix granulata is somewhat indifferent to direction but negative to intensity.

No experiments were performed with nymphs of *Tetrix granulata* because the early stages of this form were not available at the time this work was in progress.

Here, again, as in the case of the experiments on phototaxis, we find an exact correlation between the reaction of the insects and the conditions in the habitat in which they occur.

(b) Reactions to Colors.—An attempt was made to find out reactions of grasshoppers to the different colors of the spectrum. The apparatus used was the same as that used in the former light experiments with the exception of a few modifications. A cover for the container was made from colored gelatine sheets supplied by the Central Scientific Company, Chicago, (Catalog No. F7153) and arranged in the order—violet, blue, green, yellow, orange, and red. The light was furnished by three forty watt Mazda lamps placed 30 centimeters above the container so that the light was equally distributed.

The data below are averages made from twenty readings. One reading taken every 5 minutes. Five grasshoppers were used.

Color Tests.

	Adults.						Nymphs.					
	V.	B.	G.	Y.	O.	R.	V.	B.	G.	Y.	O.	R.
Melanoplus femur rubrum	0	7	28	46	2	17	5	7	29	24	16	19
Melanoplus differentialis	12	12	13	16	19	28	1	10	19	12	33	25
Dissosteira carolina	12	10	30	26	13	9	17	13	39	13	12	6

There is a general preference for green and yellow in both nymphs and adults of *Melanoplus femur rubrum* and *Dissosteira carolina.* The nymphs and adults of *Melanoplus differentialis* prefer orange and red. This is in agreement with other light reactions in which insects prefer shade or darkness.

2. *Reactions to Surfaces.*

Field observations show that grasshoppers vary in the kinds of places where they alight, some alighting on flat surfaces of leaves, others on stems. There are distinct differences in the species, as well as a difference in adults and nymphs of a species. For example, *Dissosteira carolina* alights on bare ground, *Melanoplus differentialis* usually on stems. The nymphs of *M. differentialis* or *M. femur rubrum* are usually found on leaf surfaces, while the adults alight on stems. Experiments testing this point were carried on using practically the same apparatus as in the light tests. Instead of the adjustable cover, a glass plate was substituted. Square sticks of mint, round stems of various plants, strips of corrugated paper, mica, pebbles and sand were used as bottom covering. Readings were taken and averages made as in the foregoing data.

D. carolina.		*M. femur rubrum.*		*M. differentalis.*	
Smooth surface.	Sticks.	Smooth surface.	Sticks.	Smooth surface.	Sticks.
78%	22%	44%	56%	32%	68%

D. carolina showed no preference for the sticks. They crawled over the sticks, always taking the smooth surface of the pan. *M. femur rubrum* followed the sticks after coming in contact with them. In very few cases did *M. femur rubrum* walk on the smooth surface of the pan. *M. differentalis* also showed a decided preference for the sticks. In experiments in which large, small, and square sticks were used, *M. differentalis* were very active when on sticks of small circumference, but were very inactive when in contact with sticks of larger circumference.

In experiments with nymphs and adults of *M. femur rubrum* in which mica was used the adults showed a preference for the bits of mica. They would jump from the bits of mica to the smooth surface, moving about actively until coming in contact with the rough edges of the mica. The nymphs showed little preference for the mica.

Adults *M. femur rubrum.*		Nymphs *M. femur rubrum.*	
Mica.	Smooth surface.	Mica.	Smooth surface.
76%	24%	56%	44%

Nymphs and adults of *M. femur rubrum* were tested with sticks of corrugated paper, stems of mint, and triangular sticks of wood.

Adults *M. femur rubrum.*		Nymphs *M. femur rubrum.*	
Sticks.	Smooth surface.	Sticks.	Smooth surface.
64%	36%	32%	68%

The adults alight on round stems, the nymphs on flat surfaces.

3. *Reactions to Temperature.*

Temperature plays an important part in the life of a grasshopper. Some are found in cool shaded habitats, others in dry barren places.

In the experiments gradients were established and maintained by placing two pans on the water table and allowing hot water to flow into one, cold into the other. A third pan was set across these two so as to allow the water to come in contact with the cold at one end and the warm at the other, (Shelford '17, p. 406). Sand and black loam were used as a floor in the pan. Temperatures of 50° C. (hot) and 25° C. (cold) were maintained. Readings were taken as in the light tests, averages in per cents given on twenty readings.

Adults *M. femur rubrum.*		Nymphs *M. femur rubrum.*	
Hot 50°C.	Cold 25° C.	Hot 50° C.	Cold 25° C.
67%	33%	46%	54%

The nymphs were inactive in either temperature. All experiments showed a slight preference for cool temperatures. Experiments in which nymphs of *M. differentialis* were used showed a decided negative reaction.

Adults were subjected to the same temperatures.

D. carolina.		*M. femur rubrum.*		*M. differentialis.*	
Hot 50°C.	Cold 25°C.	Hot 50°C.	Cold 25°C.	Hot 50°C.	Cold 25°C.
84%	16%	60%	40%	28%	72%

D. carolina moved out of the cool area in the pan and became inactive in the warm area. *M. differentalis* were much agitated upon coming into the warm area and would either turn directly around, moving to the cool area, or jump ahead into the warm sand, moving about actively, finally jumping to the cool area. *M. femur rubrum* were not so active as either *D. carolina* or *M. differentialis*. *M. femur rubrum* are slightly positive to heat.

4. *Reactions to Gravity.*

The apparatus used to demonstrate reactions to gravity consisted of glass jars 45 centimeters high and 25 centimeters in diameter with a glass plate used for a cover. Upright partitions were made of corrugated paper. Wooden sticks, stems of various plants, and strips of corrugated paper were placed vertically. Leaves of burdock, plantain and pieces of paper were placed on the floor of the jars.

The experiments did not show very decided results, probably on account of phototactic stimuli entering, and altering the response to gravity.

In the field *M. femur rubrum* and *M. differentialis* crawl up the stems and, upon reaching the top, jump, usually alighting on the ground, or on a stem that is nearer the surface than the former position. They then proceed to crawl up again.

In the experiments *D. carolina* showed a decided positive geotactic response. This species, which in nature is found on the ground, remain on the floor of the container.

	Floor.	Stems.
M. differentialis.		
Adults	36%	64%
Nymphs	72%	28%
M. femur rubrum.	Floor.	Stems.
Adults	22%	78%
Nymphs	65%	35%
D. carolina.	Floor.	Stems.
Adults	74%	26%
Nymphs	90%	10%

5. *Experiments in the Evaporating Power of Air.*

Experiments were performed to determine the reactions of grasshoppers to air of different evaporating powers. The apparatus was essentially the apparatus described by Hamilton ('17 p.-160) and Weese ('17 p.-102). The experiments covered a period of forty minutes. Readings were taken every two minutes. Five grasshoppers were used. The first, fifteenth, and

twentieth readings, and averages of twenty readings being given.

M. femur rubrum.

Readings.	Minutes.	Adults. Humidity. 80	55	25	Nymphs. Humidity. 80	55	25
1.	2	2	0	3	3	1	1
15.	30	1	1	3	1	0	4
20.	40	0	3	2	1	0	4
Averages in per cents for twenty readings		25	38	37	27	12	61

In all species there is a tendency to show a preference for dry air, nymphs showing a greater preference than adults. The above data are typical for all species studied.

Table Showing Reactions to Environmental Stimuli.

Explanation of Symbols:
P—Positive.
N—Negative.
I—Indifferent.

Stimuli:	*M. differentialis.* Brook margin. Adults.	Nymphs.	*M. femur rubrum.* Sweet clover. Adults.	Nymphs.	*D. carolina.* Clay bank. Adults.	Nymphs.	*T. granulata.* Marsh. Adults.
Light	N	N	P	N	P	N	I
Intensity	N	N	P	N	P	P	I
Direction	N	N	P	N	P	P	N
Colors	(orange and red)		(green and yellow)		(same)		(same)
Rough surface	P	N	P	N (slightly)	N	N	N
Temperature	N (to warm)	N	P (to warm)	I	P (to warm)	I	N (to warm)
Gravity	P	N	P	N	N	N	N
Preference for dry air	P (slight)	P (slight)	P (very)	P	P (very)	I	I

The foregoing table briefly summarizes the reactions of the grasshoppers to the various factors of their environments. These reactions as have been repeatedly pointed out are correlated with the difference in the habitats chosen by the various species and stages of development as observed in the field, and may be regarded as explaining the distribution of the grasshoppers in their natural environment.

V. Conclusions.

1. Grasshoppers segregate themselves into different animal associations. This habit is little affected by choice of food, but rather according to response to light, surface contact, temperature, gravity, and the evaporating power of air.

2. Nymphs and adults select somewhat different habitats, and show a corresponding difference in their reactions to en-

vironmental stimuli. Thus, nymphs choose broad, flat leaf surfaces of the lower strata, adults take positions on the stems.

3. Four stations were studied; the brook margin, clay bank, sweet clover, and temporary marsh. Each station had its distinctive species. *Melanoplus differentialis* is found on the brook margin; *Dissostiera carolina* on the clay bank; *Melanoplus femur rubrum* in the sweet clover; *Tetrix granulata* on the temporary marsh.

BIBLIOGRAPHY.

ADAMS, C. C.
1913. *Guide to the Study of Animal Ecology*, New York.

CAMERON, ALFRED E.
1916. *The Insect Association of Local Environmental Complex in the District of Holmes Chapel, Cheshire.* Transactions of the Royal Society of Edinburgh, Vol. LII, Part 1, (No. 2), pp. 37,77.

FOX, HENRY.
1914. *Data on the Orthoptera Faunistics of Eastern Pennsylvania and Southern New Jersey.* Acad. Nat. Sci. of Phila. June, 1914.

SHELFORD, V. E.
1911. *Physiological Animal Geography.* Jour. Morph. Vo.l 22, pp. 522–618.
1912. *Ecological Succession v. Aspects of Physiological Classification.* Biol. Bull., Vol. XXIII., pp. 331–370.
1913. a. *Animal Communities in Temperate America.* Chicago.
1913. d. *The Reactions of Certain Animals to Gradients of Evaporating Power of Air.* A Study in Experimental Ecology. Biol. Bull., Vol. XXV, pp. 79–120.
1914. a. *Modification of Behavior of Land Animals by Contact with Air of High Evaporating Power.* Jour. An. Behavior, Vol. IV, No. 1, pp. 31–49.
1914. b. *The Significance of Evaporation in Animal Geography.* Ann. Assn. Am. Geog., Vol. III, pp.29–42.
1917. *Suggestions as to Field and Laboratory Instruction in the Behavior and Ecology of Animals with Descriptions of Equipment.* School Science and Mathematics, Vol. XVII, No. 5, pp. 388-409.

VESTAL, ARTHUR G.
1914. *Internal Relations of Terrestrial Associations.* American Naturalist, Vol. XLVIII, pp. 413–444.
1913. b. *An Associational Study of Illinois Sand Prairie.* Bull. III, State Lab. Nat. Hist., 10, 1–96.

WEESE, A. O.
1917. *An Experimental Study of the Reactions of the Horned Lizard, Phrynosoma Modestum Gir., A Reptile of the Semi-Desert.* Biol. Bull., Vol. XXXII.

MUNITIONS DIRECTOR SHOWS U. S. HAMPERED BY LACK OF METRIC STANDARDS.

In his monumental report, "America's Munitions," just issued, Benedict Crowell, Assistant Secretary of War and Director of Munitions, reveals that the United States was hampered in the World War because we did not use the metric system of measurements employed by the French and all our other allies, except Britannia. In numerous instances he shows that the lack of universal standards of measurement meant that in the making of munitions, the American ordnance engineers lost weeks, and "even months of time on the part of whole staffs of experts working at high tension."

Concerning the manufacture of the famous "75" cannon, the report says: "To avoid delays and confusion, we decided to redesign the American and British guns (of similar size) to make their bores uniformly 75 millimeters, thus simplifying the ammunition problem and making available to us in case of shortage the supplies of shell of this size in France."

World Trade Club of San Francisco has urged that the United States adopt the Metric System, not only because of its superiority to our present weights and measures, but also in order that our nation be able to go speedily to the aid of France, and co-ordinate our resources with hers, in case of future attack.

HOW CAN SEX EDUCATION BE MADE A PART OF GENERAL SCIENCE?[1]

By E. F. Van Buskirk,
DeWitt Clinton High School, New York City.

Both general science and sex education are new subjects in the curriculum. They, therefore, need to be defined. By general science I understand is meant the science of everyday life, and by sex education instruction which leads to a normal, wholesome attitude of mind toward sex problems.

In order to understand how sex instruction can be made a part of general science, it first is well to have an outline of a course in general science in mind. The outline which will be given is the one which is used in the DeWitt Clinton High School of New York City. The course is divided into two parts. In the first term, the pupils study about the chief necessities of life: air, water, and food. They study about these subjects from the point of view as to how man uses them, with special reference to health and disease prevention. It is impossible to go into much detail regarding the content of this course. Only the main features can be mentioned.

Regarding the study of the air, the pupils learn first that air is a real substance, although invisible. They learn about ways in which man makes use of air; for example, as in the use of the barometer, various pumps, draughts for fires, etc. In studying about how the body uses air, they learn about the working of the respiratory system, and first aid for persons partially asphyxiated. Regarding disease prevention, they learn the cause, the manner of spreading, and the general nature and effects of such diseases as consumption, pneumonia, and diphtheria, diseases which attack the respiratory system. Under the subject of water, they study how it is obtained and used in the home. They learn something about the method of purifying water and how such a disease as typhoid fever may be spread by drinking impure water. They learn something about the effect of water in the soil, in connection with erosion and with the life of plants. In the study of food they learn the elementary facts concerning its manufacture in plants, and how the human body uses food, and how it is prepared and preserved at home.

In the second term's work they study about the forces of nature and how man uses them. This is done under two heads. First, they learn about subjects connected with warmth and

[1]Paper given at the North Carolina High School Teachers Conference, Raleigh, N. C., February 15, 1919.

protection. Such topics as the building, lighting and heating of homes, and the care of clothing, are considered. The second sub-heading for this part of the term's work is the work of the world. Here is taken up the study of everyday machines, means of communication, methods of transportation, and finally, the subject of the origin of life and its betterment.

It becomes evident that the subject of sex education is closely connected with this last-named topic. However, the work in the first term has laid a foundation for later study of some problems related to sex. Just how this works out will be explained later.

The subject of sex instruction I would put under four heads. First, there is the work treating of the origin of living forms; second, the subject of venereal diseases; third, the study of the physiology and hygiene peculiar to the period of puberty and adolescence; and fourth, the study of heredity.

In connection with the study of the origin of living things, the following named forms of life should be taken up: flowering plants, a few of the lower forms of plants and animals, fishes, birds, and mammals. After the study of flowering plants, the pupils will have obtained a vocabulary which will assist them in studying other forms. Thus they will learn the meaning of such terms as "sperm cells," "eggs," and "fertilization." They will come to use these terms in reciting, just as they would use the terms, "saliva," "stomach," "digestion," "respiration," "circulation," etc.

It seems to me that the most important effect of this kind of teaching is that the pupils are led to take a normal viewpoint of such a subject as reproduction. They see it in its normal relationship and they come to understand that there is nothing inherently unclean in such a subject. If properly presented, a reverent attitude of mind will have been assumed toward the topic, for they will have learned of the fact that no one, not even the most distinguished scientist, entirely understands what happens when a baby plant or animal is produced.

The second topic, that of venereal diseases, should be treated very briefly when taken up with first year high school pupils. After they have learned about ways in which consumption, pneumonia, typhoid fever, malaria, and possibly a few other diseases are spread, and how they may be prevented, they will readily understand the general nature of venereal diseases. Especially if they have actually seen bacteria growing on petri

dishes and examined them under the miscroscope, they will have had a foundation that will be helpful. In taking up this subject with boys, I find that from ten to fifteen minutes is sufficient time to give to it. The following facts are brought out: first, that syphilis and gonorrhea are practically always produced or spread only through sexual intercourse, and that practically all prostitutes sooner or later suffer from one or both of these diseases. Second, that the result of these diseases constitutes one of the greatest scourges of society, producing such results as blindness in babies, sterility, insanity and death. It is not necessary to paint the picture as black as it actually is. Certainly there is no need for exaggeration.

Concerning the physiological changes of puberty and adolescence, there are different facts which should be presented to boys, in contrast with those which should be presented to girls. Both, however, should understand the general significance of the internal secretion which is made in the reproductive organs—how this secretion produces in the boy the manly qualities which are universally admired, and in the girl, corresponding womanly qualities. The adolescent boy should know that "nocturnal emissions" are normal occurrences, providing they do not occur oftener than once in ten or twelve days. The girl should understand that menstruation is a normal function, and she should be given instructions concerning its hygiene. The boy should be warned against the advertisements of quack doctors; and he should be informed concerning the harmful results of masturbation.

The fourth topic which should be discussed in sex instruction in general science is concerned with heredity. In treating of this subject plant and animal breeding should be studied. Luther Burbank's work is of special interest. The pupil should know the meaning of such terms as variation, selection, and hybridization. The influence of environment upon living organisms should also be studied. After these subjects have been treated, the child will be able to understand the principles of eugenics. For first year high school pupils, it is probably unwise to attempt to treat these subjects in anything except an elementary manner. However, reference to the "Kallikak" family and the "Jukes" should be made and compared with the descendants of such a person as Jonathan Edwards. It is well to emphasize the positive aspect of this subject, rather than the negative. If this is done, the result will be one of inspiration to

the pupils. A high school pupil is not too young to think at times about the future when he will help to make a family and to realize that the kind of family of which he is to be a part will be determined to a great extent by the kind of life he is leading at present.

The work which has been outlined is intended for either the junior high school or the first year of the four-year high school. Three or four weeks' time is needed to treat the subjects properly, five times a week. It is not necessary that the subject, as outlined, be treated consecutively. It probably would be better to take it up at such times in the course of the term's work where it naturally comes in. Two to three weeks are needed to do justice to the subject of the origin of life. One week is needed for heredity. Two lessons will probably be sufficient for the consideration of the physiology and hygiene of puberty and adolescence, and ten to twenty minutes will be sufficient for the consideration of venereal diseases. Reference to gonorrhea and syphilis can be brought in with the lesson upon the physiology and hygiene of the organs of reproduction. The discussion of the normal functioning of the body should receive much more attention than the subject of disease.

As has already been indicated, the work is to be an integral part of the course in general science. As has been outlined it is intended for classes segregated according to sex. If the classes are mixed, the study of the physiology and hygiene of human reproduction, together with that of venereal diseases, probably should not be treated at all. However, almost all of the work upon the origin of living forms, together with the subject of heredity, can be taken up by an experienced teacher, even in mixed classes.

The methods of instruction in sex do not differ from the methods of instruction in other topics. The laboratory will have to be used for the study of the origin of living forms, and also some laboratory exercises can be worked out upon heredity. These topics should then be discussed according to the usual recitation methods. In presenting the subject of the physiology and hygiene of human reproduction and the question of venereal diseases, the methods should be that of the lecture, the pupils not being asked to recite upon the questions involved.

It seems to the writer that there is opportunity in this work for often employing the project method. This is true because of the fact that pupils have a very live interest in the questions

involved. Long before they reach the high school, they have asked such questions as the following: "Where do babies come from?" "How does the chick get into the egg?" "How did the plant come out of the seed?" "Why am I like my father or my mother?" These questions are natural starting points for study. It is true that some of them should have been answered before the high school age. However, one of the functions of sex instruction in high school is to do this very thing: to answer normal questions which have arisen in the child's mind and for which he has not as yet received authoritative and wholesome answers.

What are the results of instruction of this kind? It has already been mentioned that one of the results of the careful instruction regarding the origin of living forms is a reverent and clean attitude of mind toward the subject of reproduction. It has been the writer's experience in his classes to see boys who at first were inclined to smile and treat in a light way these questions, afterwards take them up in a wholesome manner, without any evidence of self-consciousness. If the subject of venereal diseases is properly treated, the result should be that the pupils will determine never to expose to their ravages either themselves or those whom they hold most dear. As an illustration of this fact, the author recently received a letter from a boy in the U. S. Navy, who stated that he had been leading a clean life because of the instruction which he had received in high school. At the same time, he stated, many of his companions were suffering from the effects of venereal diseases. The result of instruction concerning the significance of the physiological changes of puberty and adolescence should be beneficial in many ways. Again I could cite instances from class room experiences in this matter. The case of one boy who wrote me that he had broken away from a group of evil-minded companions and had given up the habit of self-abuse, stands out prominently in my mind. This boy had markedly improved in his school work and in his ability to get enjoyment out of life, as a result of self-control. Concerning the topic of heredity and eugenics, it has been the writer's experience that pupils are intensely interested and consider the work of practical value.

It should be understood that no one subject in the course of study can furnish complete instruction in the line of sex education. All that general science can do is to make a contribution to this end. At the beginning of this paper the subject of sex

education was defined as including all instruction which would lead to a normal, wholesome attitude of mind towards sex. This definition is not as specific as it should be. There has been too much instruction in high school without a clearly defined goal in the mind of the educational authorities who have required the work. More and more will the public demand that courses of instruction be made to meet definite needs and interests of pupils. As in other kinds of instruction, so in sex education, the teacher should have very clearly in mind the exact goal or aim that is involved. This goal should also be in the pupil's mind, at least, to the extent that the child is able to comprehend it. It will probably not be as clearly defined in the mind of the pupil as in the mind of the teacher. This aim seems to me to have been very well expressed by one of the greatest men of our age—Theodore Roosevelt. In speaking concerning the duty of an individual to society, he said, "The highest duty, the one essential duty, is the perpetuation of the family li e, based upon the mutual love and respect of the one man and the one woman, and upon their purpose to rear healthy and high-souled children."

THE ORGANIZATION OF SELF-RATING BLANKS.

Dr. H. O. Rugg, of the School of Education, has completed the first two of a series of rating forms for judging students, teachers, prospective teachers, and administrative officers. The essential feature of the cards is that they are constructed in such a way as to enable an individual to rate himself and at the same time provide a definite method by which a teacher may rate a high school student, or an administrator a teacher. The key of the scheme is "self-improvement through self-rating." One rates himself by answering definite questions concerning the extent to which he does or does not do certain things. The form for rating high school students and teachers in service will be followed in the autumn by others for prospective teachers in schools of education and normal schools and administrative officers.—*School Review.*

DEVELOPMENT OF GROUP INTELLIGENCE TESTS.

During the war great impetus was given to the development of general ability or intelligence tests by their use in the examination of army recruits. A very efficient instrument for intelligence examinations exists in the Stanford revision of the Binet Scale, but for general application a test which can be given to entire groups simultaneously and scored rapidly is necessary. The army tests were designed for the adult level. Dr. F. N. Freeman and Dr. H. O. Rugg have been at work on a group test which is intended particularly for the junior and senior high school students. Two parallel forms of the test of approximately equal difficulty are approaching final form. They are printed and ready for distribution at a moderate price, three cents each. This price includes instruction and scoring sheets and blank forms for the tabulation of results.—*School Review.*

DIRECT READING BOYLE'S LAW APPARATUS.

By H. C. Beltz,
Salt Lake City High School.

The apparatus shown in the illustration is to determine the relation between the pressure and the volume of a gas. It is direct reading, that is, no mathematical computation is necessary to get either the volume or the pressure of the gas. It was made in the physics laboratory of the Salt Lake City High School at a small cost and can be made in any high school. The apparatus is suitable for studying the pressure volume relation both above and below atmospheric pressure. The readings can be taken readily and quickly. One piece of apparatus ought to supply the needs of a laboratory where several experiments are being worked at the same time.

P is a pressure gauge graduated in pounds absolute, with a maximum reading of 45 pounds. V is a glass tube 1-2 in. inside diameter. On P the pressure of the gas is read, on V its volume. The remainder of the apparatus is made from 3-4 in. gas piping, all joints between the different members being made air tight by coating with red lead mixed with turpentine before being screwed into place. At A and B are stop cocks, the one at A

to get the desired adjustment of the liquid in the apparatus, the one at B to maintain the pressure while readings are being taken. At B a force pump is attached to produce pressures above the atmosphere and an aspirator or suction pump to produce pressures below the atmosphere. The liquid to transmit the pressure may be colored alcohol or oil. The glass tube sets into a pipe coupling on each end. The inside diameter of the coupling is greater than the outside diameter of the tube. The joint is made air tight by filling this space with melted ceiling wax. The apparatus is mounted on a board 4 ft. x 1 ft. x 1 in. The pressure gauge is firmly fastened to the board by screws, the pipes are held rigidly in place by cleats.

The most expensive part of the apparatus is the gauge. A good gauge can be bought for $2.50 or $3.00. If a cheaper gauge is used it may be necessary to recalibrate it. In calibrating the glass tube for volume the curved tube on the inside of the pressure gauge will have to be taken into consideration. Its volume can be found by filling with water.

RADIUM MINERALS.

Ores and Location of Deposits.

Radium minerals are generally found in connection with granitic masses—that is, in places where granite forms at least part of the rock of the country. Most of the original radium minerals such as uraninite samarskite, and brannerite, are black and have a shiny fracture and a high specific gravity. These minerals are rarely found in commercially valuable quantities. Pitchblende, which has the same composition as uraninite and the same general appearance except that it shows no crystal form, occurs in veins. It has been found in only a few places—in Bohemia, southern Saxony, Cornwall, and Gilpin County, Colorado. When these original minerals break down through weathering other radium minerals are formed from them, such as autunite, torbernite, carnotite, and tyuyamunite.

The Most Abundant Radium Minerals.

Carnotite and tyuyamunite are the most abundant of these minerals and now furnish the bulk of the world's radium. They can not be told apart by the eye, for both are of bright canary-yellow color and are powdery, finely crystalline, or, rarely, claylike in texture. Carnotite is a hydrous potassium-uranium vanadate. Tyuyamunite is similar in composition but contains lime instead of potash. The greatest known deposits of these two minerals are in southwestern Colorado and southeastern Utah, where both are associated with fossil wood and other vegetation in friable, porous, fine-grained sandstone. Small quantities of carnotite have been produced near Olary, South Australia. The only other deposits that yield tyuyamunite in notable quantity are those of Tyua-Muyun, in the Andiyan district, Ferghana Government, central Asiatic Russia (Russian Turkestan), where tyuyamunite occurs with rich copper ores in a pipe in limestone.

INTRODUCTORY COURSES IN BOTANY II.

By Bradley M. Davis

University of Michigan.

(*Continued from October.*)

Outline No. 4.

A half-year college course, 2 lectures, 6 hours of laboratory work, and 2 quizzes each week.

1. Structure of a sunflower leaf. Morphology and histology (brief study).
2. Living cells of a leaf of Elodea. Protoplasmic structure and movements, plasmolysis, osmosis. Effect of temperature changes on rate of movement.
3. Reactions of mimosa leaf to stimuli (largely demonstrations.)
4. Chemical constituents of living matter (largely demonstrations). Sugars: test for different forms. Starch: structure and tests. Cellulose: relation to protoplasts, tests. Manufacture of carbohydrates: experiments illustrating and contrasting photosynthesis and respiration. Fat: tests on oil, milk, kernel of nuts. Protein: tests on white of egg.
5. Structure and functions of a sunflower stem. Histology of sunflower stem. Support, conduction, storage.
6. Starch formation in storage cells in stem of Pellionia. Chloroplasts, leucoplasts.
7. Structure of a sunflower root. Root system, root hairs, histology.
8. Structure of embryonic cells in a root tip of onion from prepared slides.
9. Nuclear and cell division in the root tip of onion.
10. One-celled plants. Bacteria, Chlamydomonas, yeast. Structure and study of life habits from cultures.
11. Spirogyra. Structure and reproduction.
12. Bread mold. Structure, life habits, reproduction.
13. Corn smut. Structure, life habits, reproduction.
14. Wheat rust. Structure, life habits, reproduction.
15. Fucus. Morphology, reproduction, fertilization with special reference to sex differentiation.
16. Marchantia. Morphology, reproduction, life history. Discussion of chromosome reduction and its relation to the alteration of generations.
17. Moss. Morphology, reproduction, life history. Some discussion of Sphagnum and its practical importance.
18. Fern. Morphology and histology, reproduction, life history.
19. Isoetes. Morphology and fructification of sporophyte with explanation of life history.
20. Zamia. Morphology and fructification of sporophyte. Gametophytes from slides. Life history.
21. Pine seed. Structure, comparison with seedling.
22. Roman hyacinth and lily or other convenient monocots. Morphology and fructification of sporophytes. Gametophytes from slides. Life history.

22\. Corn fruit. Structure, food substances, germination.

23\. Monocot stem. Histology of corn stalk compared with stem of sunflower.

24\. Cucumber or other dicot. Morphology and fructification of sporophyte. Gametophytes from slides. Life history.

25\. Bean seed. Structure, foods, germination.

26\. Structure of woody stem compared with corn and sunflower.

"Some of the fundamentals of botany are taught through the study of a limited number of types representing the great groups; the forms selected are, so far as possible, those of economic importance or which for other reasons are already more or less

familiar to the student. For the most part the plants studied are arranged in an evolutionary sequence; but experience has shown that there are certain advantages in beginning the course with a study of the vegetative parts of a seed plant (the sunflower being a convenient type for this purpose) in connection with which are presented certain basal ideas of anatomy and physiology, including the constitution and organization of living matter. The relationships of the plants studied within their respective groups, as well as the interrelationships of these groups, are discussed in the lectures so far as limitations of time allow."

OUTLINE No. 5.

A course planned for students in an agricultural college. The numbers in parentheses after each topic refer to the number of actual periods (144 in all), including lecture, laboratory, and quiz set aside for each subject. The course would, therefore, require a full year, 4 periods a week, or with 8 periods a week might be given in a half year.

1. Introduction to botany (1).
2. The life of the plant (2).
3. Fundamental internal structure of the plant body (6). Cell structure, cell division, forms of cells, contents and products of cells.
4. Water relations of plants (8). Importance as a limiting factor in crops and plant associations. Functions of water in the plant. Intake of water: structure of roots, distribution through the plant, factors affecting water intake. Outgo of water: structure of leaves, factors affecting outgo. Water requirements of crop plants and adaptations to drought. Man's control of water relations.
5. Heat relations of plants (3). Importance in growth and distribution of plants, effect on rate of growth. Distribution of crops in relation to temperature. Man's control of temperature relations.
6. Light relations of plants (6). Importance in growth. Classification of plants according to light requirements. Effects of light: chemical (carbohydrate synthesis), heating, stimulus, morphogenic. Light quantity and quality. Man's control of light relations.
7. Nutrient relations of plants (12). The two great groups of plants based on nutrient relations. Chemical substances and elements in the makeup of plants and essential to growth, sources for independent plants. Chemical forms in which elements enter the plant. Food of green plants. Synthesis of foods. Digestion and translocation, assimilation. Man's control of nutrient relations.
8. Transportation and storage of materials (8). Need and structure of transporting system. Forms in which food is stored. Storage tissue. Relation of stored material to growth. Plant products of commercial value.
9. The flower, chiefly in relation to reproduction (12). Structure, pollination, fertilization. Types of flowers. Self-sterility and self-fertility. Parthenogenesis.
10. The fruit (8). Development, distinction from seed. Classification of fruits (economic plants as examples). Failure of blossoms to set seed.
11. The seed (12). Structure, germination, seedling. Conditions necessary for germination. Seed testing.
12. Vegetative multiplication (4). Essential nature. Methods: by roots, stems, leaves.
13. Growth (8). Conception and mechanics. Growth in length of stems and roots, primary and secondary growth. Effect of environmental factors on growth.
14. Classification and naming of plants (4).

15. Algae (6). What they are and where found, structure, nutrition, reproduction. Destruction of algae in ponds, reservoirs, etc. Economic uses.

16. Fungi and plant diseases (12). Economic significance of plant diseases: causes, classification. Character of casual organisms: morphology, nutrition, reproduction, ecology. Symptoms of important plant diseases: control (general principles).

17. Bacteria (4). Structure, nutrition, reproduction, decay, soil fertility, sterilization, diseases.

18. Mosses and liverworts (3). General character, life histories, economic uses.

19. Ferns and their allies (4). General character and distribution, life histories. Economic uses.

20. Seed plants (4). Gymnosperms and angiosperms compared. General characters, distribution, economic importance.

21. Plant evolution (3). Meaning: inorganic and organic. Methods: important hypotheses, sources of evidence, tendencies.

22. Improvement of plants (9). Theories of heredity. Individuality, elementary species, pure lines. Mass selection compared with individual selection. Hybridization. Mendelism.

23. Weeds (3). Weed problem in the United States, losses. Nature of weeds, how spread. Principles of weed control. Important weeds of the United States.

24. Forestry (3). Kinds of forest trees. Forest regions of the United States, value. Timber: rate of growth, uses. By-products of forestry. Forest service, conservation, reforestration.

"The viewpoint of this course is to use economic plants as far as possible, to relate subject matter to the industries, to give up the idea of developing phylogenetic relationships, make physiology and ecology the backbone of the course, present subject matter in the form of problems of fundamental importance, inject masculinity into the subject and get as far away as possible from the notion that Botany is the study of flowers."

Outline No. 6.

A twelve weeks college course, 2 lectures, 6 hours laboratory work weekly.

1. Cyanophyceae. Studies on Gloeothece, Nostoc, Oscillatoria.

2. Chlorophyceae. Studies on Pleurococcus, Ulothrix, Cladophora, Oedogonium, Vaucheria, Spirogyra.

3. Phaeophyceae and Rhodophyceae. Some general studies on diversity of form.

4. Schizomycetes. Observation of bacteria with some simple cultural experiments.

5. Phycomycetes. Studies on Mucor.

6. Ascomycetes. Studies on powdery mildews and other sac fungi.

7. Basidiomycetes. Structure and life history of wheat rust. Studies on Agaricus, puff balls, earth stars, birds-nest fungi, and stink horns.

8. Liverworts. Detailed studies on Riccia and Marchantia making use of prepared slides for difficult features. General study of some leafy liverwort. Detailed study of Anthoceros with slides.

9. Mosses. Structure and life history of some common moss in detail with slides. General study of Sphagnum.

10. Filicales. General morphological studies on some available common ferns, sori, sporangia. Histology of stems (slides). Prothallus.

11. Equisetales. General morphology and fructification of Equisetum.

12. Lycopodiales. General morphology and fructification of Lycopodium and Selaginella.

13. Cycadales. Morphology and fructifications of Zamia. Sections of ovules (slides).

14. Coniferales. General studies on various conifers. Staminate and ovulate cones of pine.
15. The flower. Structure from tulips or other similar flowers. Stamens, cross sections of anthers (lily) from slides. Pistil, free hand section of stigma, ovary.
16. Development of ovule and embryo sac of the lily (slides).
17. Comparative studies on available flowers, floral diagrams.
18. The leaf. Comparative studies on form and venation. Histology from fresh material and prepared slides.
19. The stem. Experiments with ascent of safranin solution in cuttings of Coleus and histological examination. Histological studies on stems of dicotyledons—Tilia, geranium—of monocotyledons—corn.
20. The root. General studies on Coleus. Histology from prepared slides of Ranunculus.
21. Seeds and seedlings.

"This scheme of laboratory work is accompanied by lectures on morphology and relationships with references to physiology and ecology in appropriate connections. The plan of the course is to make comparative morphology the matrix to be flavored with small samples of other phases. Morphology is selected because it seems logical that a study of structure should precede a study of function and that a general survey should precede a more detailed examination."

"The course is planned to emphasize a point of view. Students intending to go no further in botany and using the course simply as a part of their general culture, are not interested in detail, but rather in a brief general survey. For this reason emphasis is laid not so much on presenting numbers of facts as the method of using facts. To teach a point of view, the facts must be clearly organized and logically arranged, and for this reason morphology is at present in a better condition than physiology or ecology, or any other separate phase and certainly better adapted to this requirement than any complex of subjects."

(*To be Continued.*)

TIN IN 1918.

Tin is one of the few highly useful metals that are practically not produced in the United States proper. The output of tin from domestic ore in 1918 was only 68 tons, nearly all of it obtained from placers in Alaska.

The tin imported in 1918, as metal and in concentrates, amounted to 82,854 short tons, the largest quantity yet brought into the country in any one year.

Deposits of tin ore are found in California, Virginia, North Carolina, South Carolina, South Dakota, Washington, Nevada, and New Mexico, but the ore at some of them contains so little tin that it can not be mined with profit.

Tin concentrate from Bolivia was handled at four tin-smelting plants in this country, which produced from it over 10,000 tons of metallic tin.

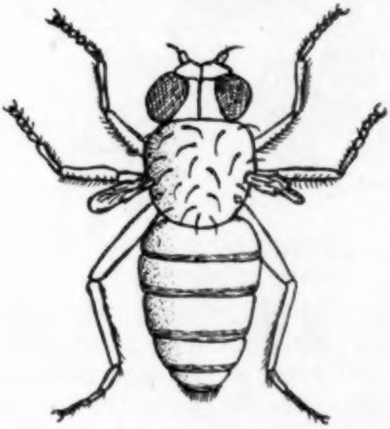
A report on tin in 1918, by Adolph Knopf, has just been published by the United States Geological Survey, Department of the Interior, as a chapter of Mineral Resources for 1918 and can be obtained free of charge on application to the Director of the Survey at Washington.

DROSOPHILA AND MENDEL'S LAW.

By Eugene M. Landis,

4401 N. Ninth Street, Philadelphia, Penn.

Various species of the fruit-fly, *Drosophila*, have been used to prove numerous phases of Mendel's Law. Excellent results in accordance with the Mendelian Ratio were obtained in several experiments with *Drosophila ampelophila*. *Drosophila* was used because of the comparatively short time in which several successive generations can be procured. The average time for the development of the adult from the egg is ten to fourteen days, depending upon the temperature. On account of this fact two generations can be obtained in less than a month.



Drosophila ampelophila
Female with Vestigial Wings.

Two varieties of *Drosophila ampelophila* were used: a wild variety having long wings with all the characteristics of the Diptera and a second variety having short vestigial wings but in other details like the first type. (See Drawings.) The object of the experiment was to ascertain how closely the ratio between long-winged and vestigial-winged descendants accorded with the Mendelian ratio for a single pair of contrasting characters in the parents. Mendel, after studying the phenomena of hybridization in the garden pea, deduced the ratio to be 3 : 1 and explained and proved this ratio both in theory and experiment.

Small six ounce quinine bottles were used as containers for the flies, the bottom of each bottle being covered with sour banana mash to a depth of half an inch or more. Several pieces

of crumpled filter paper were placed above the mash to absorb any surplus water that might be standing in the bottle because the flies are easily drowned. A small piece of cotton placed loosely in the mouth of the bottle prevented the escape of the flies. A virgin female with long wings and a male with vestigial wings were put into one bottle. These two individuals constituted the *parental generation.* The female was a virgin because she was removed from all males before she had reached the age of six hours after her emergence from the pupa case. The female *Drosophila* is not sexually mature until seven or eight hours

Drosophila ampelophila
Female with Long Wings.

after emerging from the pupa stage. Hence any spermatazoa that fertilized her eggs must have come from the male with vestigial wings. After one or two days the female began to lay her eggs on the side of the jar and on the filter paper. In two or three days more the eggs hatched and minute white maggots crawled around in the mash. When the larvae grew to be about an eighth of an inch long they began to pupate, forming around themselves a yellowish brown papery covering. They remained in this state from three to four days after which the adult flies appeared, emerging from the pupal case by eating a small hole through one end.

As soon as the pupae appeared the parents were removed and killed. When the first filial generation (designated as F_1 in the diagrams) emerged from the pupa stage they were etherized and counted to ascertain the number of males and females. The character of the wings of each fly was also carefully observed. The results showed that every individual of the first filial generation had long wings, though *all* were hybrids of parents whose characters were directly opposite with respect to their wings.

The flies were removed from the bottle daily. In four successive days there emerged 142 flies, each one having long dipterous

wings. Seventy of these were males and seventy-two females. The individuals of this generation were all hybrids whose germ plasm contained determiners or potentialities for both long and vestigial wings. These potentialities produced the characters observed in the body of the animal. There were present in the germ plasm of the hybrids two kinds of determiners, those for long wings and those for vestigial wings. All the flies of the first generation had long wings, however, which shows that when the two sets of determiners are present in the germ plasm of the

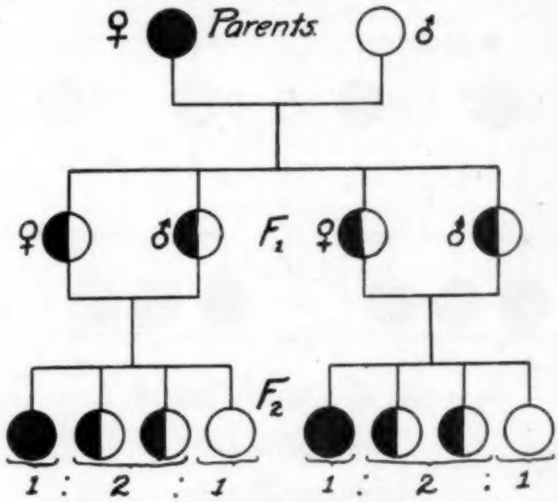


Diagram to Show Mendel's Law
as Applied to
Genotypes.
Black Represents Determiners
for Long Wings which are Dominant

fly, those for long wings dominate those for vestigial wings and produce flies with long wings. The determiners for short wings would have produced flies with short wings if the determiners for long wings had not been present. The character that appears in the first filial generation is called a dominant character, while the character that recedes temporarily is called a recessive character. In *D ampelophila* long wings are dominant as is shown by their presence in the first generation. Nevertheless the germ plasm is not pure with respect to the long winged character but is composed also of short winged determiners as shown in the diagram of the genotypic or germ plasm constitution.

From the individuals of the first generation there were chosen four males and four females as parents for the second filial generation (designated by F_2 in the diagrams). A large number of individuals is always desirable in an experiment of this kind because the larger the number of individuals observed, the more

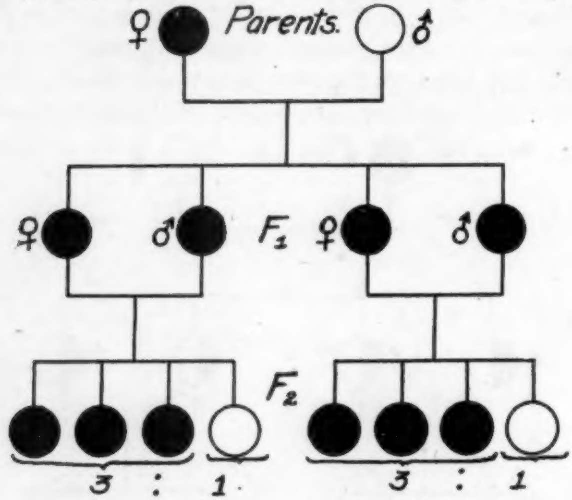


Diagram to Show Mendel's Law as Applied to Phenotypes.

Black Represents Long Wings Which are Dominant Characters.

correct and reliable will be the results obtained. When the adults of the second filial generation emerged from the pupal stage there were both long winged and vestigial-winged flies present. The removal of the adults from the bottles began ten days after the parents were mated and were as follows:

Date	Flies with Vestigial Wings	Flies with Long Wings
May 22	1	33
23	27	77
24	28	107
26	93	224
27	24	82
Totals	173	523

It will be noticed that the number of flies with long wings is approximately three times as great as the number of flies with short wings. The ratio is 3.02 : 1, whereas the ratio as deduced theoretically is 3.00 :1. These results refer only to the pheno-

typic or body characters. In the diagrams the genotypes and phenotypes are compared. Whenever determiners for long-wings are present in the genotype, the fly is a long winged specimen. It is only when the germ plasm consists purely of determiners for short or vestigial wings that the phenotype is of the short winged variety.

The ratios are all based on the laws of chance and therefore the result will never be exactly the same as the theoretical ratio but as the number of individuals observed increases the amount of difference decreases. These results show in a rather crude way the correctness of the Mendelian Ratio for a single pair of contrasting characters.

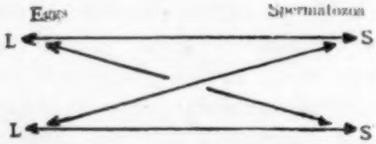
The Mendelian Ratios are based on three fundamental principles which, taken collectively, are termed "Mendel's Law." The first of these is the principle of "Unit Characters." Every organism inherits from its ancestors certain characteristics of body such as size, shape, color, etc. These characters are inherited as units or as a whole through the agency of the determiners which are found in the germ plasm. The chromatin substance of the zygote nucleus contains determiners which by their presence stimulate the cleavage cells to produce the body of the adult animal with all its peculiarities.

The constitution of any germ cell (i. e. egg or sperm) is said to be a genotype while the evidence of that germ cell constitution in the body of the animal is called a phenotype. The body or the morphological characters of any animal make a phentoype. The characters appearing in the phenotype are inherited as a whole. The heritage of any animal can be divided into a greater or lesser number of characters that are inherited as units and therefore these characters are said to be "Unit Characters."

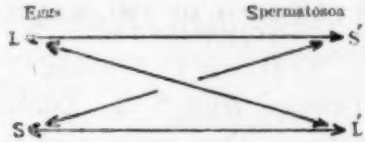
The second principle is that of "Dominance." If two parents are chosen which have contrasting unit characters, one of these characters will appear fully developed in the first filial generation while the other will recede from sight. The unit character which appears in every individual of the first generation is called a *dominant* character. That character which recedes from view in the first filial generation is a *recessive* character. In the case of *Drosophila* the long wings are the dominant character while the vestigial wings are the recessive character. There are marked exceptions to this principle of Dominance in cases where absolute dominance does not exist but a blending occurs as in the Primroses where the hybrids of red and white parents appear pink in color in the first generation.

The third principle is that of "Segregation." In the zygote of the hybrid Drosophila of the first generation there are determiners for both dominant and recessive characters. In the earlier stages of the cleavage of the egg a certain cell or group of cells are set aside to become germinal cells. These germinal cells are either male or female. When they divide to form germ cells (i. e., eggs or spermatazoons) the determiners for unit characters are so segregated that each germ cell is pure with respect to any given unit character. Each sperm or egg cell must be composed purely of determiners for long wings or purely of determiners for vestigial wings. No egg or sperm can contain determiners for both characters. Thus in the germ cells the segregation produces eggs and spermatazoons whose genotypes are either totally dominant or totally recessive.

With these principles in mind the phenomena observed can be explained. In the parental generation all of the eggs of the female had the same constitution because all held determiners for long wings only. Each spermatazoon of the male possessed the same constitution as the others because they all held determiners for short wings only. Thus the eggs would all have a constitution "L," where "L" denotes the presence of determiners for long wings. The spermatazoa would all have a formula "S," where "S" denotes the presence of determiners for short wings.



As will be seen from the diagram the only possible union of these determiners in the zygote will be "LS." It cannot be "LL" or "SS" because neither egg nor sperm can begin cleavage unless fertilization has taken place. Thus every individual of the first generation will have the same genotype and phenotype. All will have long wings because the determiners for long wings are dominant. As shown in the diagram of the genotypic application of Mendel's Law, each zygote will have equal quantities of determiners for long and vestigial wings. Consequently, by the principle of Segregation we must recognize two kinds of eggs and sperms in the individuals of the first filial generation. Half of the eggs will have determiners for long wings and half for short wings. The same is true of the spermatazoa.



As shown in the diagram an egg cell containing determiners for long wings might be fertilized by a sperm nucleus containing determiners for short wings. In the same way the egg with determiners for long wings might combine with a sperm of determiners for long wings. The first zygote would be a heterozygote because it contains determiners for each of the contrasting characters while the second would be a homozygote because it contains determiners for only one of the contrasting characters. All possible combinations would be therefore LL′, LS′, L′S, SS′.

Since there are two ways of producing an "LS" zygote there would be twice as many of those as of the other two genotypes because there is twice the probability for such a union according to the laws of chance. For every four individuals there would be three genotypes. Three of the four individuals would contain determiners for long wings. Hence three adults out of four would have long wings but the remaining adult out of each four flies would have short wings, because it is a homozygote with respect to short wings.

By the laws of chance the ratio for genotypes would be

LL : 2LS : SS
1 : 2 : 1

The ratio for phenotypes would be

3 Long : 1 Vestigial.

In the diagram the relation of the genotype to the phenotype is represented by black shading to show the determiners in the genotypes and the characters themselves in the phenotypes.

The experimental results obtained bear out this conclusion. The number of individuals for each genotype or phenotype depends altogether on the action of chance, and the probability for each union. As a result it is essential to observe a large number of flies.

If the number of vestigial-winged flies be multiplied by 3 the result is 519 as compared to 523 which is the number of long-winged flies. These results therefore indicate the truth of the conclusion that Mendel formed from the results he obtained in his extensive experiments with the Garden Pea.

SUBSTITUTES FOR SOME OF THE WRITTEN WORK IN CHEMISTRY.

By Hattie D. F. Haub,

Oakland Technical High School, Oakland, Calif.

During the last two or three years many chemistry teachers have felt that the written work in chemistry, both the "write-ups" of experiments and the written reviews, often uses valuable time of student and teacher that might be far better employed. Unless the mistakes are corrected immediately, corrections are of doubtful value; and even when time is planned for it in advance, it is too often impossible to look over the papers at once. If the written work is not done in class there is always the temptation to the weaker student to use at home the written work of preceding classes if not that of his own mates.

In experiments involving data, much valuable help can be given the student in teaching him to write concisely that which he did, and in teaching him to record data properly. No pupil writes, "I opened the match-box, took out a match and rubbed it along the side of the box until there was a flame," because he is familiar with such a reaction. But many pupils write, "I placed the sulphur on the left hand side of the balance and the weights on the right side. Then I counted the weights twice," etc., especially if it is the first time the balance is used. Only by repeated writings and corrections can the students learn to differentiate between the important parts of the experiment and the details of the procedure. Again many students use the "I" until the paper bristles with egotism; and most of them have no notion of recording data. The most effective way of having them learn the things mentioned above is to require the experiment to be written up somewhat as follows:

Experiment 3. Density.

Object. To determine the density of sulphur.

Procedure. A small piece of sulphur was weighed to the nearest decigram and carefully slipped into a graduate containing exactly twenty cubic centimeters of water. The increase in volume was noted.

Data and Calculations.

1.	Weight of sulphur	10.1	g.
2.	Volume of water	20.	c. c.
3.	Volume of water and sulphur	25.	c. c.
4.	Volume of sulphur (25 − 20)	5.	c. c.
5.	Density of sulphur (10.1 ÷ 5)	2.02	g./c.c.

Sometimes queer results are obtained when the student first attempts to do without the "I." One dull but anxious-to-please

boy upon being told to use the third person, painstakingly rewrote his experiment saying, "They weighted a piece of sulphur and then they filled a graduate," etc.

An ordinary one year high school chemistry course contains many descriptive experiments which readily lend themselves to different treatment. In an attempt to make better use of the time allotted to the study of chemistry the writer tried the following plan. No laboratory manual is allowed in the laboratory. Every experiment is discussed before it is performed so that the student knows what chemicals he is going to use and why he is to use them. In the early part of the term the kind of apparatus to be used for a given experiment is talked about. If several students have different ideas concerning the setting up of the apparatus, each presents his view, probably draws a sketch of his apparatus on the board and then the class discusses the good and bad points of each plan. To illustrate the above, suppose the class were to make hydrogen chloride. From previous work with the gas, they know that hydrogen is one constituent of the hydrogen chloride, and very likely some student knows that chlorine is the other constituent. The first suggestion given by the class may be that hydrogen chloride can be made by chemcally combining hydrogen and chlorine. By further questioning it can be easily developed that two substances, one containing hydrogen and the other chlorine, which will interact readily may be used. The question as to whether or not there is any "best" chloride or "best" acid always arises. Then too the amount of materials that should be used, how the gas obtained should be collected, what tests should be tried with it, etc., are questions that must be considered in more or less detail depending on the previous work of the class. When an experiment is preceded by such a discussion, the student goes about his work intelligently. His attitude is far different from that shown when he reads a sentence out of the manual, measures out a quantity of salt, reads another sentence, and then starts off for some acid, and so on throughout the experiment, depending continuously on the manual, a crutch necessary because of the lameness of his chemical knowledge. On the other hand if he performs the experiment without the manual he already has definite knowledge and there is not much advantage in a detailed "write-up." Instead each student may be asked to have ready about ten minutes before the close of the period, a paper on which he has neatly written the properties of the substance he has learned from his experiment; the

equations for reactions, if he has reached the equation writing stage; or an explanation of some phenomena he has just observed. These papers are corrected then and there, and the students allowed to grade them themselves. If one student found six properties and another only two, the second student realizes his own shortcomings far better than if his paper had been returned to him with an unsatisfactory mark from the teacher. The students are generally surprisingly strict in their grading. Many of the poorer students are decidedly encouraged in their laboratory work when they see the results their fellow workers are able to attain.

Several experiments result in products which may be neatly mounted, labeled, and handed in. For instance such experimental work as that done in dyeing, soap-making and coloring of borax beads needs no detailed writing up. In fact a student might write correctly the colors he obtained with the borax beads, having his statements tinged with information he has gained from reading.

Ex. 40. Borax Beads.

Material Used	Oxidizing Flame	Reducing Flame
Cobalt nitrate	0	0
Manganese dioxide	0	0
Ferric Chloride	0	0
Copper sulphate	0	0
Nickel nitrate	0	0
Potassium bichromate	0	0

To illustrate the method of mounting material obtained in learning the properties of wool and cotton the following is given.

Ex. 1. Properties of Substances.

A. Materials boiled with dilute sodium hydroxide solution.

Wool dissolved.

B. Materials dyed with eosin.

C. Drawing of the fibres (100x).

The samples in the experiments just enumerated may be fastened on with paste or slits may be made in the paper and the samples threaded in.

It has been the writer's experience that where the above scheme rather than detailed writing is used with suitable experiments, much time is saved and better laboratory work is done. Each student wants the best possible samples to hand in.

Written examinations still infest the schools and sometimes it seems impossible to get along without them. But often laboratory reviews can be substituted for written reviews with

most gratifying results. Many a poor student will most confidently assert that his laboratory work is good, and merely telling him that there is real labor in a laboratory doesn't bear conviction. It is generally useless to try to explain that the effervescence resulting from adding hydrochloric acid to zinc is not because of the student's splendid manipulation but because of the ability of these substances to react when allowed to come in contact. However, a laboratory review will convince the student of the need of thinking as well as memorizing if he is to succeed.

After working with hydrogen most students will glibly repeat without any real appreciation of what is meant, that the metals above hydrogen in the Displacement Series will displace hydrogen from some of its compounds such as acids; that hydrogen unites with oxygen to form water, etc.

Probably in an ordinary written review, they could answer correctly eighty per cent of the questions. But the teacher's self satisfaction is apt to receive its death blow if the same students are given a laboratory test such as, "Candle wax has hydrogen as one of its constituents. Prove it." Those pupils who do not think will add an acid to the wax because they have somehow connected hydrogen and an acid. There is a splendid chance here for making more definite, these vague ideas. The student who lights his candle and holds a cold object in the flame, thereby collecting carbon instead of water vapor, offers a good topic for class discussion. Probably some student will heat some wax with copper oxide and rejoice at discovering copper and water vapor as products of the reaction. One youth in such a test handed in a paper saying, "There is no hydrogen in wax. When heated even calcium will not displace it." In the class discussion of that point later another member of the class answered "That doesn't necessarily prove anything because sodium doesn't displace the hydrogen from the kerosene."

Among other subjects which have been found feasible for laboratory reviews are the giving of unknowns such as starch, barium hydroxide, citric acid, oxalic acid, and potassium chlorate to the students in order that they might determine whether they had an acid, base, salt, or some other substance not an ionogen. Tests with indicators, taste, feeling and conductivity of the solution can be tried. After the study of carbon dioxide, unknowns such as granite, colored marble, white marble, ferrous sulphide, etc., can be used and the student asked to determine which are carbonates.

When carbohydrates have been studied each student is asked to bring a potato. Then he is given a definite laboratory period in which to obtain starch from it. Later he converts this starch into glucose. Corn is sometimes used instead of the potato. Various other foods are brought from home and tested for reducing sugar and for starch. The presence of starch in frankfurters, gumdrops, and marshmallows is a surprise, and few students expect to find sugar in onions.

After working with various oxidizing agents, cotton waste can be used as a test substance to be bleached.

Instead of having the student answer in writing, the question, "In how many ways can you make sodium chloride?" let him try to actually do it in the laboratory. Apparently more time is required when the latter method is used but by the end of the term the student will have a working and not just a book knowledge of his subject. The results obtained when first using the laboratory type of review generally cause much revision in the original teaching. The teacher ceases before long to ask questions which demand only conscientious memory work on the part of the student.

STUDIES OF FOSSIL PLANTS IN THE SOUTHERN STATES.

Students of the remains of plants that are found in long-buried rocks in different parts of the world are gradually learning more about the forms of vegetation that existed on the earth ages ago and that were the precursors and progenitors of living plants. The beds of coal that furnish most of the power and some of the light by which the modern world does its daily work are made up of the remains of plants that lived millions of years ago and that, dying, entombed their stored-up sunshine to run the wheels of human industry.

The results of some recent studies of the fossil remains of plants later than those that formed our eastern coal beds are given in a report just issued by the United States Geological Survey, Department of the Interior, entitled *Upper Cretaceous Floras of the Eastern Gulf Region in Tennessee, Mississippi, Alabama, and Georgia*, by E. W. Berry (Professional Paper 112). Professor Berry describes nearly 200 species of plants from remains found at 23 places and presents half-tone views of more than a hundred specimens and of some of the beds in which they were found. The nature of the plants studied and the geographic and geologic positions in which they were found give some clues to the climate and the geography of the region in which they lived, and though the conclusions reached by Professor Berry as to these features are given by him with proper reservation and caution they nevertheless afford interesting suggestions and show how the paleobotanist can aid in the interpretation of ancient geography.

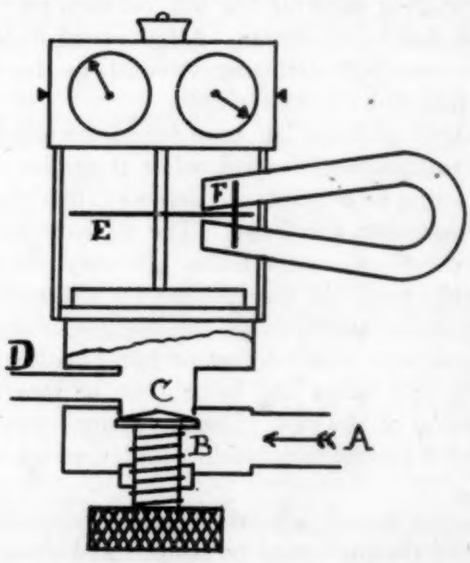
This paper is of interest and value to geologists and to students of paleobotany, who can obtain copies free on application to the Director, United States Geological Survey, Washington, D. C.

THE USE OF THE SIREN IN PHYSICAL LABORATORIES.

By WILL C. BAKER,
Queen's University, Kingston, Ont.

Simple sirens of the Cagniard de la Tour type are described and discussed in almost every text-book on General Physics. They are shown in almost every lecture course on Sound. They consist usually of a wind-box surmounted by a disc with obliquely bored holes, that carries on the upper end of its spindle a simple counting mechanism. This instrument is seldom used by the students in actual determinations of pitch, chiefly on account of difficulties in speed control. Mechanical methods are not sufficiently uniform, and electromagnetic devices, while ideal in some respects, are usually of too small a range. A combination of the two, however, has enabled the writer to secure an unusually instructive and satisfactory laboratory exercise. The disposition of apparatus is described in this note.

The air pressure is obtained by means of a small centrifugal blower (0000 Pressure Blower, Sturtevant) which is belt-driven from a motor. To diminish the hum of the motor and fan, the air is led to the apparatus in an adjoining room through a length of garden hose. The air enters the control valve, as shown by the arrow at A. B is a flat cone, carried on a screw,



which by means of a knurled head may be moved toward or from the end of the tube C. This provides the rough control as

the speed of these sirens depends on the rate of air supply. The air now has two paths, one through the tee, D, to which the organ pipe is attached by a bit of rubber tube carrying a screw clip (to regulate the air going into the pipe), and the other directly into the wind-box of the siren. Rigidly attached to the spindle of the siren is a disc of copper, E, that rotates between the poles of a toy magnet, which is clamped to the frame of the instrument. The magnet is shunted by its armature, F, as shown.

The experiment requires two observers. The motor is thrown on full voltage so that it supplies a greater pressure than is actually needed, and so that variations in the pressure delivered to the siren may be compensated for by appropriate action of the valve at C. The screw clip at D is closed down until the pipe is sounding gently. The armature of the magnet is taken off and the position of B adjusted so that the siren runs just too slowly—giving say four or five beats per second with the pipe. It may be noted that as both of the sounding systems are driven from the same wind-box the beats are very pronounced and are easily heard. The fine control is now affected by placing the armature across the arms of the magnet, a position being soon found for which the siren runs at nearly the constant speed desired. Moving the armature nearer the prongs of the magnet increases the short circuiting, thus reducing the flux between its poles and so permitting the disc to run faster. A movement in the other direction lessens the short circuiting, strengthens the field cutting the disc, and thus slows down the siren.

After the above position has been found one student devotes his attention to the speed control, while the other observer operates the counting mechanism. A series of runs, each of one or two minutes duration, are taken. The student controlling the speed does it entirely from the beats. He may either try for an average coincidence of the two pitches by alternately speeding up or slowing down the siren as the beats appear; or he may keep the siren always just too fast or just too slow so that the other observer can count the beats (one or two per second) during the period of the run. The necessary correction to the value obtained from the revolution counter may now be easily made.

The exercise, as usually given in this laboratory, involves the measurement of the pitches of both open and closed pipes, and the comparison of results with those calculated from the application to the dimensions of the simple theory usually given in texts,

which, until then, is taken without criticism by the student. Quite apart from the determination itself, from the focussing of attention on the beats, on the Focault currents, the departure from simple theory is valuable, in that it forces the student to a more critical examination of his own work. After examining the conditions of the experiment and the concordance of his experimental results the student usually acquires a confidence that sends him back to an inquiry into the assumptions of the textbook treatment with results that are educational in the widest sense of the term.

Attempts to avoid the use of the copper disc by applying the magnet directly to the brass disc of the siren have not led to encouraging results.

THE MONKEY CLIMBS AGAIN.

By Wilbert A. Stevens,
Township High School, Lockport, Illinois.

This magazine of 1917, page 821, contained a reference to Lewis Carrol's problem of the climbing monkey. The writer of that article, William F. Rigge of Creighton University, Omaha, Neb., quotes the problem (from L'Astronomie of July 1917) in this form. "To one end of a rope passing over a fixed pulley, a monkey is climbing, while his equal counterpoise is fastened to the other. The monkey now begins to climb up the rope. What happens to the weight at the other end?"

The original problem focused on the monkey. Mr. Rigge seems to take it for granted that the monkey will go up, and confines his attention to the balancing weight. He says that remains stationary "because the monkey cannot change his weight and that is balanced by the counterpoise." Suppose Mr. Rigge change the problem to read "The monkey now begins to pull the weight up. What happens to him?" I assume that on the basis of the reason given above he would reply, "The monkey now remains stationary." Well, each of these results might no doubt follow in Wonderland.

But Mr. Rigge further asserts that experiment proved his explanation correct. The works of an old clock, arranged to wind up a string were counterpoised over the pulley of a fine Atwoods machine. The works went up, the counterpoise remained stationary.

Of course when fact contradicts hypothesis, the hypothesis has short shrift; but when well established theory is challenged, it is prudent to check up on the "fact." The theory here involved is that if the monkey is to rise against the resistance of gravity, force must be applied, and that to the action of this force there must be an equal and opposite reaction. Assuming friction negligible, the reaction is of course transmitted through the rope to the counterpoise which must then rise also. Did Mr. Rigge take the trouble to determine whether the friction was negligible? His weight of 240 grams mounting 80 centimeters per minute required a power of approximately 0.03 watt, so that a very little friction would absorb the reaction. If he will repeat his experiment, readjusting relations between weight, power and friction, he will find that both monkey and counterpoise invariably travel in the same direction at the same rate.

ELEMENTARY PHYSICS IN THE SCHOOLS OF THE PROVINCE OF ALBERTA.

By Philo F. Hammond

For the last three years (1916-1919) the writer has personally conducted or supervised all of the classes and laboratory work of the department of physics at the University of Alberta during the absence of the regular members of the staff who were on active service for the British Government in England and in France.

Practically all freshmen in the university are required to take physics. The students in the faculty of agriculture come from the three provincial "Schools of Agriculture" which give special courses differing from those given by the high schools and are in a class by themselves at the university and need not, therefore, be considered here. Freshmen from all of the other faculties, except the faculty of applied science (engineering), are required to take a three hour lecture course. Freshmen from the faculty of medicine and from the school of pharmacy are required to spend one period of three hours each per week in the laboratory in connection with the lecture course. Students may enter the university as freshmen after taking three years high school work except in the faculty of applied science. Students entering this faculty are required to complete four years of high school work or to complete the freshman year in the faculty of arts and sciences. With the exception of a few special cases, students of the faculty of arts and sciences have no laboratory work. Including the several faculties there were about ninety students in attendance at the lectures all in one class. During the fall and winter one period per week was devoted to "quiz" for which purpose the class was divided into three or four sections, but it was found necessary during the last third of the session to give the entire time to the lectures.

Among the students who had no laboratory work the number of failures was entirely out of proportion to the size of the class. The results of the instruction given were unsatisfactory, and the instructor was more and more impressed with, what seemed to him at least, the fact that students of his classes, some years before in a high school working under different conditions, left the class with a better working knowledge of physics than did the students from the faculty of arts and sciences in the classes just mentioned. The work of the former high school classes was so conducted that the student spent a fairly large proportion of

his time doing laboratory work, and the class work and the laboratory work were so correlated that there was no fixed d - vision of time, the laboratory work preceding, if possible, the class work. This led him to send out to the high schools of the province the questionnaire given below in order to get in touch with the whole field of elementary physics teaching in the province.

The summary of this questionnaire will be better understood by the American teacher if a brief outline of the course in physics in the high schools of Alberta is given. In general the courses given in the high schools of the Dominion of Canada differ from those in most states in the United States in that they follow the extensive plan rather than the intensive plan. In most schools of the United States many subjects (as plane geometry and physics) are completed in one year of thirty-five to forty weeks of five 45-minute recitation periods per week with double periods for laboratory work, the student devoting his entire time to four subjects. In the Canadian high schools there are usually fewer recitation periods per week devoted to the subject and these are usually shorter in duration. Three or four years are given to the subject and the student takes many more subjects than is allowed in most high schools in the United States.

In the Province of Alberta thirty minutes seems to be the most popular length of recitation period. The number of recitation periods per week and the length of each period, however, seems to be a matter for each school to decide for itself and depends entirely upon the judgment of the principal, or teacher, and the conditions. Physics is studied in the high schools of Alberta in each of the four years of the course. *Elementary Physics*, by Merchant and Chant, and the *Ontario High School Physics*, by the same authors, are the accepted texts of the province. The *Ontario High School Physics* gives about the same grade of work as "Millikan and Gale" or "Carhart and Chute," texts more or less familiar to American teachers. The *Elementary Physics* is not so hard and is used usually in the first two grades while the other is used in the eleventh and twelfth grades. A few schools, however, use the larger book in all four grades.

In general the course is planned as follows: Grade IX: Mechanics of Solids and Fluids. Grade X: Heat, Magnetism, and Electricity. Grade XI: Sound and Light. Grade XII is devoted to a review of the whole course in which the work is

given in more detail, and some parts omitted during the first three years are covered. Physics is required in the first two years of the high school.

Questionnaires were sent out to twenty-seven public and separate high schools in the province.[1] Twenty-one replies were received, but the data from one could not be used. The questionnaire contained the following questions:

(1.) Name of school.

(2.) Text book used.

(3.) Grades in which physics is taught.

(4.) Number of recitation periods per week in each grade.

(5.) Number of laboratory periods per week (in which the student performs the experiment personally and writes up his results).

(6.) Length (in minutes) of each recitation period.

(7.) Length (in minutes) of each laboratory period.

(8.) Value of apparatus for the study of physics.

(9.) What preparation for the teaching of physics has the physics teacher? (State general and special.)

(10.) Subjects, other than physics, taught by the physics teacher.

(11.) Remarks.

The following is a summary of the reports:

(3.) Grade IX, twenty schools; Grade X, 20; Grade XI, 20; Grade XII, 12.

(4.) For Grade IX, nine schools reported 2 recitation periods per week; eight, 3; two, 4; and one, 5. Mean, 2.8 periods per week. For Grade X, three reported 2; eleven, 3; four, 4; and two, 5. Mean, 3.25 periods per week. For Grade XI, three reported 2; eight, 3; six, 4; and three, 5. Mean 3.4 periods per week. For Grade XII, one reported 1; two, 2; two, 3; five, 4; and two reported 5. Mean, 3.4 periods per week.

(5.) For Grade IX, sixteen schools reported no time given to laboratory work; three, 1 period per week; and one, 2 periods per week. For Grade X, fourteen schools reported no laboratory work; five, 1 period; and one, 2 periods. For Grade XI, thirteen schools reported no laboratory work; four, 1 period; and three, 2 periods. For Grade XII, eight schools reported no laboratory work; three, 1 period; and one, 2 periods.

---

[1]A separate high school (in the Province of Alberta) is a public school under a board composed of members of the Roman Catholic Church primarily for children of parents of that faith and supported by a division of school funds. Taxes paid by patrons of such a school are used for its support.

(6.) Grade IX, one school 25 minutes; nine, 30 minutes; five, 35 minutes; two, 40 minutes; two, 45 minutes; and one, 60 minutes. Mean, 35 minutes. Grade X, one, 25 minutes; seven, 30 minutes; four, 35 minutes; four, 40 minutes; three, 45 minutes; and one, 75 minutes. Mean, 37 minutes. Grade XI, one, 20 minutes; five, 30 minutes; four, 35 minutes; four, 40 minutes; four, 45 minutes; one, 70 minutes; and one, 90 minutes. Mean, 40 minutes. Grade XII, two, 30 minutes; three, 35 minutes; four, 40 minutes; two, 45 minutes; and one, 90 minutes. Mean, 42 minutes.

(7.) Grade IX, four schools; two, 35 minutes; and the others 25 and 30 minutes. Mean time per week, 37 minutes. Grade X, six schools; three, 30 minutes each; two, 35 minutes; and one, 25 minutes. Mean time per week, 37 minutes. Grade XI, seven schools; two, 30 minutes; and the others as follows: 20, 45, 50, 60, and 70 minutes. Mean time per week, 55 minutes. Grade XII, four schools as follows: 30, 40, 45, and 60 minutes. Mean time per week, 50 minutes.

(8.) Six replies contained no answers. One school gave under $100; one, $100; one, $150; one, $175; two, $200; one, $250; two, $300; one, $500; and one, $1,500. One answered "well equipped" and two "sufficient for work required."

(9.) The answers to this question were of little value because they were too general, as: "Honor graduate in science," "first class certificate," "Specialist in science," "B.A.—four years' experience," etc., and no correct classification is possible. Roughly, the following classification may be considered as an approximation: Three teachers with only high school physics, three with one year in a university, five with two years, one with three, three teachers with special courses preparatory to teaching physics, and six teachers with special science courses.

(10.) Three of the papers contained no replies to this question. One school reported no other subjects; one, chemistry only; one, 1 other subject; two, 2 others; one, 3; three, 4; three, 5; three, 6; one, 7; and three, 9 other subjects. This of course does not tell the whole truth since all algebra may be considered as one subject and it is taught in at least three grades. The same is true of other subjects such as geometry, Latin, etc.

Little comment upon answers to questions (4) and (6) is necessary. The summary will be plain to the reader. However, one striking thing in this report, to the American teacher, will at once be noticed. This is the large amount of time given to

the class work in the high schools of Alberta. Assuming that an average of two days a week is given to laboratory work, as is usual in the American high school, then the high school student in Alberta spends over three and one-third times as much time in the class room as does the American student. Or, if we assume that the American student takes no laboratory work; but attends class five times per week, then the Alberta student spends twice as much time in the class room to cover the same ground.

If one were to make a survey of the physics teaching in all of the high schools, large and small, in a relatively new state (e.g., South Dakota[2] or Arizona) one would expect to find conditions far from ideal, especially as regards laboratory work.

We would expect, however, to find the laboratory work fairly well developed in the larger towns and cities. Calgary and Edmonton have a population of about 60,000 each. The population of Lethbridge may be taken as close to 10,000 and that of Medicine Hat close to 7,000. It is probable that but few of the other towns in Alberta are over 3,000. Most of the towns having high schools range between 300 and 3,000 with a possible average of about 1,200. The smallness of these towns and the fact that the country is new perhaps accounts in part for the deplorable lack of laboratory work, and the small amount of money invested in laboratory apparatus shown by the reports. The remarkable thing is, however, that a few of the smaller high schools are doing more laboratory work than are some of the larger ones.

No report was received from Medicine Hat. Lethbridge reports one period of thirty minutes per week in each of grades ten, eleven, and twelve, and an exceedingly small amount of money invested in laboratory apparatus for the size of the school. The physics teacher teaches four other subjects besides physics. It is probable, under the circumstances, that the teacher is endeavoring to do his duty, but it is evident that apparatus is lacking, laboratory periods are too short, and the teacher is required to teach too many subjects.

The two Calgary high schools and the separate high school at Calgary do no individual laboratory work. In these schools the teachers perform the experiments before the class and a certain amount of these are written up by the students. The students of the

[2] "Science Teaching in South Dakota," by Hilton Ira Jones. School Science and Mathematics, Vol. XVIII, January, 1918, page 76.

Edmonton (Separate) High School do no individual laboratory work. All that is done at the Victoria High School (Edmonton) is one period of forty minutes per week during the fall term in the twelfth grade. In the Strathcona High School[3] (Edmonton), however, the students of each grade spend one period per week in the laboratory, of thirty-three minutes each in grades nine and ten and of sixty minutes each in grades eleven and twelve. The value given for apparatus is "approximately $1,500," three times as much as that given by any other high school. The results of the work of the students from this high school in the classes at the university show the effects of their high school training in physics.

This article has been made longer than it should be in order to make it clear to the large number of American readers. It is not the aim of the writer to contrast the results of the work of the schools in Alberta with those of any other province or state (he hasn't the facts at hand to do so if he wished), but it is only fair to explain to the American reader that the ideals of science teaching in the secondary schools of Canada approach more nearly the ideals of European schools than the ideals of American schools. Less value is given to laboratory work and more to class room demonstrations by the teacher, and it is to this fact rather than to any lack of progressiveness that the conditions in the larger schools mentioned above may be attributed. Those who have had to teach students from the American high schools or who have made a survey of any science in such schools know only too well how far below American ideals the science teaching in the high school actually is. However, the Canadian teacher will find that the Canadian student will profit as much by well organized laboratory work properly carried out as does the American student, and that no demonstration work on the part of the teacher, however commendable and essential such work may be, can take its place. It is not only necessary for the teacher to see the needs of better conditions, but to bring them about requires the concerted action of teachers, supervisors, and school boards.

The Department of Education or the University might aid teachers and school boards in the purchase of apparatus. During the war, supplies from England were cut off. Last year the writer found one school supply concern in Eastern Canada,

[3]Mr. Curtiss, who had charge of the classes in physics and chemistry at the Strathcona High School at the time the questionnaire was made, was a man of rare teaching ability. He succumbed to an attack of pneumonia at the time of the epidemic last fall.

handling apparatus of a Chicago apparatus company, charging from 50 to 100 per cent more than the company at Chicago charged for the same apparatus. Since apparatus for school purposes enters Canada duty free, there is no reason why schools should be fleeced in this way.

Unfortunately the answers to question (9) were given in such a way that it is impossible to tell much about the preparation of the teachers in the schools of Alberta to teach physics. Teachers carrying as many subjects as this report shows can hardly be expected to be experts in all of them and it is reasonable to suppose that physics suffers as much from lack of such preparation as any of the other subjects. The reports seem to show that many of the teachers have had no more than one year of physics in a university. All graduates from the faculty of arts and sciences at the University of Alberta have had one year of physics at the university, but few of these, indeed, would be prepared to teach the subject. What notion of the value of laboratory work, without ever having had such work themselves, can be expected of them should they become teachers?

The reader may draw his own conclusions from the answers to question (10). It would probably be better for small schools not to attempt to carry so many grades until enough teachers can be provided to do the work without being overburdened with classes.

It wouldn't be fair to the secondary schools to leave the university out of this discussion. It is the duty of all institutions of higher learning to take their students in the condition they find them and build upon what they have already attained. Some one in the Province of Alberta who had authority in shaping the courses of the University of Alberta apparently conceived the notion that all graduates from a course in arts and sciences should have covered a certain amount of work in physics, but why students from high schools, the majority of which give no laboratory work, should be subjected to the "thrilling experience" of attending a three-hour lecture course without laboratory work is as hard for the writer as it is for the majority of the students to see. If it seems impossible because of the lack of staff, apparatus or room for the university to give laboratory work to such a large number of students it would be better to allow the student to choose among the elementary sciences and require laboratory work in these sciences.

The writer wishes to thank the teachers of the Province of

Alberta for their cooperation in filling out the questionnaires. A larger per cent (78) came in than is usually the case when such reports are made. He regrets that he has been deprived of the opportunity of working with the teachers of the secondary schools of Alberta for the benefit of the coming generation and of the opportunity to personally help in the improvement of the course known as "Physics one" for the freshmen in arts and sciences at the University of Alberta by circumstances taking him to another field.

SOCIOLOGICAL ASPECT OF CHEMISTRY FOR GIRLS.

By Will Courson,
Anderson, Indiana.

The beginnings of physical science are to be found in the slow and unconscious observation of primitive races of man. Earliest mankind acquired mastery over rude implements, by the aid of which they strove to increase the security and comfort of their lives. Biological science must have begun with the observation of plants and animals useful to man. Astronomy was investigated because it was of necessity in the worship of gods. Practical medicine became of much consequence because it administered to the material needs of man. In ancient times, when knowledge of nature was small, little attempt was made to divide science into parts, and the men of science did not specialize. Aristotle was a master of all science known in his day and wrote treatises on physics and animals. An increasing knowledge made it impossible for any one man to grasp all scientific subjects, hence it became necessary to establish lines of division for convenience of study and teaching. When the study of science was admitted to the American school it was under the name of philosophy. This included in a single course the explanation of a very wide range of phenomena belonging to the several sciences of our present day reckoning. In the differentiation which followed upon the expansion of the science curriculum, this original generalized course was split into several sciences. Each has been organized into its own field without reference to the other. In a later consideration we find the colleges and universities have taken up specialized ideas of research and have thrown back into the high school the work that was formerly done in and by the colleges and universities. To some measure at least the college has become a dictator to the high school teacher who, if he is a college trained man, easily

falls in line with the subject matter offered and suggested by the college. However, if education is to form useful and specific habits and is to give useful information, it is necessary to study the sociological needs of the situation. It is not necessary, in fact it may not be wise, for a farmer to study chemistry of metallurgy or that of pharmacy. Smith says science should be taught with three motives in mind: first, the development of taste and power of appreciation; second, the acquisition of facility in the use of facts, ideas, and methodical thought processes; third, the development of scientific insights, perspectives and altitudes of mind that serve as safeguards of a well balanced training. The general aim of education from the modern vocational and sociological standpoint is to develop in the individual the highest type of personality combined with economic and social efficiency. Modern educators are returning to the old Greek idea that health is the first and most important of educational aims and any subject that neglects an opportunity to improve the community ideals along the course of sanitation and clean living has missed its highest purpose.

The early secondary schools contained only boys, and the girls were not even permitted to attend. Only the selected few of the boys were favored with the advantage. The free secondary school in our country has practically eliminated the academy and preparatory schools. Not only has our free public school attempted the college preparation and the cultural development but it has broadened itself to include training in the trades and vocations of the ordinary walks of life. Recent strides in the nation and in our own state have left educators who clamored for the highly specialized training of the leaders of society clinging to the skeleton of a fad that seems at present doomed to ultimate destruction. Yet in the present trying times of war and destruction it is more necessary than ever before that we have highly trained and efficient leaders, likewise it is as essential that the followers be trained and do their bit toward humanity's progress with the same pride and satisfaction as those who occupy the higher positions among men. If we maintain our ideals of democracy it is necessary that all have training and preparation for fitness in some small yet important place in the machinery of the community.

The attendance in the secondary schools has changed from the entire absence of girls to the position in which girls are in the majority in most high schools. Dr. Lewis finds from statistics

that about 76 per cent of the girls that enter high school are married before twenty-five years of age, also more than 95 per cent of girls that enter high school never attend college. These statistics emphasize the important responsibility thrust upon the high school. The high increase in per cent of attendance has called for changes in the curriculum. The public demands that the schools fit the pupils to take an efficient position in the social life of the community, and all should be at least exposed to an opportunity to become useful and important members of society. Eminent educators have practically agreed that the highest training that can be given girls is that which pertains to home life. Since the masses as well as the classes are to be trained, it is at least our concern to ascertain if we are giving the girls in high school chemistry and physics the subject matter that will function in their future lives.

It is impossible to know exactly what facts will be most essential in each individual student's life, but each girl that becomes a mistress of a home meets daily problems that she must solve. The responsibility of the welfare of the home should and does rest to a great extent upon this one individual. Food, clothing and shelter afford many important problems in the life of the home maker. Problems of sanitation and cleanliness confront each housewife. Around important problems many topics may be selected that are of real interest to the average girl. The topic method requires much effort on the part of the teacher, because much work is necessary to organize the material. However, the girls become more interested if real and live home problems are considered. The topic or problematic method consists in dealing with a situation as a whole, yet the method may be deductive.

"How to make good bread" is a problem that confronts each and every householder and great opportunity is afforded to apply important scientific facts and principles during the process of the discussion of the different manipulations of bread making. The idea of luck in bread making may be eliminated and in place of the almost superstitious ideas now current, satisfactory scientific answers are given to the mystifying questions. Scientific facts are eagerly learned when a definite need is felt by the individual. The subject of leavening may be easier and better taught if the pupil is led to see some practical use for the principles and facts of leavening than if the subject was separated from the vital phase of household affairs.

The problematic method affords an opportunity to utilize the motor power of the feelings. Horn says that "no idea which the feelings fail to welcome can abide in the home of the mind." Personally, I have often felt that my attempt at teaching has been a failure because the pupil has not felt, to any considerable depth, the reason, purpose or meaning of the subject matter. The material offered did not seem to function in his or her development.

The topic or problematic method affords splendid opportunity for a socialized procedure. Pupils as a rule pay more attention and manifest more interest in a discussion from a member of the class than if the same material be given by the teacher.

An opportunity for directing work, conducting drills and reviews is offered by socialized procedure. It vitalizes and adds to the interest of the work. High school people enjoy being "it" the same as the rest of us. Better preparation with less effort is quite possible but requires more effort on the part of the teacher. Many science teachers conceive the idea that if proper principles are taught and emphasized, the fact material makes little difference. The question the writer wishes to raise is: which is more important to the life of the average person, principles or facts? Facts are the fundamental basis of all our constructive thinking. Often the student is misinformed because of failure to understand the intention of the principle. The students that enter college should have the fundamentals so that a basis upon which to build may be established in the high school, but those going directly into open life need material that is unified within itself. The tasks of the average girl are in connection with home life and those of the boy are in the factory or in business life. Do boys and girls need the same science training? This is an open question. Each community differs to some extent from every other community. It is also an open question if each community can be best taken care of with the same subject matter.

It was predicted in a class in Columbia University that the science given in the high school of the future would be based upon the individual need of the community. Instead of one year of chemistry or one year of physics the time would be spent in solving the problems presented regardless of their place in the different science subjects. I was as much shocked almost as if some one five years ago would have predicted the present world war.

However, what the average woman needs in connection with home duties is not the ability to recite Boyle's or Charles' Laws or Thompson's rule, but rather the knowledge of useful facts and the application of principles that function in daily life in an economic, social or hygienic manner. She needs such facts as will help her meet the emergencies in the solution of problems in home life.

WHAT IS PRACTICAL MATHEMATICS?

By David H. Moskowitz,
Boys High School, Brooklyn, N. Y.

Almost from the day of its inception—if such a day may be regarded as having been existent—the science of mathematics and its schools of devotees had separated into contending factions—the real and the ideal. The branch denoted "real" or practical was possibly the more primitive. However, the "ideal," or conceptual branch entered early in the form of mysticism! Among the Greeks, while Euclid insisted most strenuously upon the pursuit of the "ideal," Heron was equally partisan for the "real." At a later period, when the progress of mathematics had influenced the course of civilization to a very marked degree, mathematicians of note devoted their energies equally to both branches, thereby reconciling rather than deepening the conflict between the factions.

And yet, today we are overburdened with the cry for the practical—the vocationalizing of all studies, mathematics included. Everything is scrutinized for its "bread and butter" value—witness the Perry movement in England, and the influence of the Rockefeller foundation in the United States.

Let us glance cursorily into the history of thought to determine the changes in the appreciation of mathematics as a factor in the evolution of our civilized world. To the people of his time, 550 B. C., Pythagoras and his followers were no more than impractical mystics performing "gymnastic exercises in logic," so much so that the school aroused intense political enmity resulting in its banishment and ultimate dissolution.

Euclid (300 B. C.) was regarded in the same light by the Alexandrians; Pope Sylvester 11 (1000 A. D.) was called a magician; Roger Bacon (1250) met with a worse fate than Socrates—the martyrdom of enforced silence; Galileo and Bruno, and a score of others, attest to the lack of appreciation that was bestowed upon mathematics and its allied sciences.

Yet the foundation of all great works is to be found in mathematics. In the past the applications of mathematics were first to commerce, and secondly to physical measurements.

Before 1700, there were six important discoveries or inventions; since 1800 there have been fourteen. It will be sufficiently obvious as to which of these are indebted to mathematics for their discovery or development: (1) writing, (2) numeral system, (3) compass, (4) printing, (5) telescope, (6) barometer, (7) steam engine, (8) railways, (9) steam navigation, (10) electric telegraph (11) telephone, (12) friction matches, (13) gas lighting, (14) photography, (15) Roentgen rays, (16) spectrum analysis, (17) anaesthetics, (18) antiseptics, (19) electric lighting, (20) phonograph. In the current century the influence of mathematics is still more apparent: (1) cinematograph, (2) wireless telegraphy, (3) wireless telephony, (4) electric navigation, (5) oil-driven engines, (6) aeronautics, (7) steel production, (8) submersibles.

It will be no exaggeration to state that were the applications of mathematics to be withdrawn the entire civilization of which we boast would instantly be paralyzed and the entire structure collapse like a house of sand. The mind reverts to the days when the Egyptians constructed their pyramids, when the Chinese erected their walled cities, when the Romans constructed their waterworks, baths, arenas and roadways—all before the science of mathematics had reached estimable proportions. But what a difference, what a stupendous waste of material, of human sweat and toil, what extravagance of time and life. Today, the weakest individual need but press a button or turn a lever and tons of steel rise to their predetermined position high above the heads of an admiring multitude. An official seated among luxurious comforts miles away from the scene moves a finger and a mountain of earth and water surges up from the abyss. An individual in Arlington manipulates a key and a wily Nipponese receives, in a fraction of time, information of inestimable value.

But—the objection must be voiced—this is practical mathematics; mathematics that is applicable to the demands of life. Of what use is the abstract phase? True enough; the practical has not always been practical, nor has the abstract remained abstract. When the "speculations" of the mathematicians preceded the development of other branches of knowledge they were truly abstractions. When the attendant fringe of knowledge had ceased to suffer from low visibility the abstract became the practical.

The Greeks had developed the theory of the conic sections absolutely independent of the practical use to which Kepler put them in formulating the Laws of Planetary Motion or Newton in his astronomical and gravitational systems. When Pythagoras introduced the irrational number, he suspected little of the importance to be attached thereto by every scientific calculation of our era. When John Wallis used his "imaginary" numbers he could not have foreseen their practical use and applicability in electrical science. Only to-day Prof. Pupin is utilizing differential equations in the development of telephony and telegraphy. Lord Kelvin by his abstract calculations and computations convinced people of the possibility of an Atlantic cable; suggested wireless communications, methods of recording and sending messages; invented the gyroscopic compass; developed the theory of waves; and computed the age of the earth through the radiation of heat—all through mathematical foresight. Karl Pearson, psychologist and biometrist, attests to the efficacy of mathematical method. Prof. Thompson of Aberdeen, biologist, says that "only the extremely ignorant can question the value of the conic sections."

Charles Davies, in his book, *The Logic of Mathematics*, asks: "What system of training and discipline will best develop and steady the intellect of the young, give vigor and expansion to thought and stability to action? What course of study will most enlarge the sphere of investigation, give the greatest freedom to the mind without licentiousness, and the obligations of the social compact?" Preeminence is claimed for mathematics.

COMMERCIAL FORM OF RADIUM.

Radium is a metal and is described as having a white metallic luster. It has been isolated only once or twice, and few persons have seen it. It is ordinarily obtained from its ores in the form of hydrous sulphate, chloride, or bromide, and it is in the form of these salts that it is usually sold and used. These are all white or nearly white substances, whose appearance is no more remarkable than that of common salt or baking powder. Radium, radium salts, and radium minerals are not generally luminescent. Tubes containing radium salts glow because they include impurities which the radiations from the radium cause to give light.

Radium is found in nature in quantities so exceedingly small that it is never visible even when the material is examined with a miscroscope. Radium ore ordinarily carries only a small fraction of a grain of radium to the ton, and radium will never be found in large masses, because it is formed by the decay of uranium, a process that is wonderfully slow; and radium itself decays and changes to other elements so rapidly that it does not accumulate naturally in visible masses.

MARGINAL NOTES ON CAJORI'S HISTORY OF MATHEMATICS.

By G. A. Miller,
University of Illinois.

As the recent second edition of Cajori's *History of Mathematics* is the largest and most modern general history of mathematics in the English language it is desirable and likely that a large number of the teachers of mathematics will have a copy of it in their private libraries. Hence the following list of marginal notes made, while the writer read the greater part of this book before preparing a review of it for the *Bulletin of the American Mathematical Society,* may be useful to a considerable number of other readers of this Journal.

A few of these notes have been amplified here in order to make them useful to those who may not have on hand a copy of the book under consideration. The letters *p.* and *l.* stand for page and line in this book and the suggested marginal notes follow immediately after these letters. These notes are not always corrections but relate also to additions and explanations in case the text seemed to require modifications to avoid possible misunderstanding on the part of the beginner.

P. 2, l. 6. Cf. The Thirteen Books of Euclid's *Elements* by T. L. Heath, Vol. 1 (1908), p. 154. Cajori quotes here A. De-Morgan, who used the term "Euclid's postulates," with the apparent meaning of employing the unmarked straight edge and the compass only in geometrical constructions. On consulting Euclid's *Elements* directly or works thereon, like the one to which reference is made at the beginning of this note, it will be found that the expression "Euclid's postulates" is commonly used with a different meaning.

P. 2, l. 26. Cf. note p. 98. This is one of many instances where Cajori refers to the possible Asiatic origin of our common numerals as if this origin were an established fact. The note on p. 98, on the contrary, acknowledges ignorance as regards this origin in the present state of our knowledge.

P. 10, l. 20. A triangle has three sides.

P. 11, l. 1. If the work of Ahmes was based on a much older work it is not known that this older work contained this incorrect formula. Hence the date 3000 B. C. seems questionable.

P. 11, l. 11. It is difficult to see how a geometric theorem can be "known" to be true before it has been proved.

P. 15, l. 24. Writings instead of "writers."

P. 19, l. 3. Regular solids.

P. 27, l. 27. Cf. Pascal's *Rejertorium der höheren Mathematik*, vol. 2 (1910), p. 197.

P. 30, l. 26. The *Elements* of Euclid cannot properly be called a "book on geometry" since they contain also the elements of arithmetic as is explicitly stated on p. 32.

P. 39, l. 21. The expression *sides* of right cones does not appear sufficiently clear. Cf. also *Encyclopédie des Sciences Mathématiques*, tome 3, vol. 3, p. 41.

P. 47, l. 33. The law of sines in regard to the plane triangle should have been stated more clearly, especially since it is called here "the fundamental theorem of plane trigonometry."

P. 49, l. 29. The so-called *Guldin theorem* is unclearly stated here. When a plane curve revolves it is usually said to generate a surface but not a volume. An ordinary curve is usually not supposed to have an area.

P. 61, l. 3 from bottom. Compare this statement with the following: Hence it is clear that not only did Archimedes solve the cubic equation (3) by means of the intersections of two conics, but he also discussed completely the conditions under which there are 0, 1, or 2 roots lying between 0 and a. *The Works of Archimedes* by T. L. Heath, 1897, p. CXXVII.

P. 66, ll. 1 and 23. Roman geometry was not confined to Rome. Julius Caesar seems to have employed mostly Greek surveyors, not Egyptians, to measure the land so as to secure an equitable mode of taxation throughout the empire.

P. 80, ll. 13 and 9 from bottom. According to a note in the *Encyclopédie des Sciences Mathématiques*, tome 1, vol. 1, p. 88, there is a MS. relating to determinants and due to Leibniz which is dated 1678. Write $n!$ in place of n'.

P. 83, l. 11. According to some modern mathematical historians, including G. R. Kaye, the mathematical contributions of Hindus do not justify the statement "that the Indians had climbed to a lofty height."

P. 88. Various statements on this page are not in accord with the note on p. 98.

P. 93, l. 29. If the Indians had observed "that a quadratic has always two roots" they would have been acquainted with the use of complex numbers. This is evidently not the case.

P. 96. The second paragraph could be greatly improved in form, e. g. in l. 4 the equation $\pi = \sqrt{10}$ has no connection with unit radius and the equation beginning with $\sin^2 \gamma$ would have been clearer if it had been written in the following form:

$$4\sin^2\gamma = \sin^2 2\gamma + [1 - \sin(90^\circ - 2\gamma)]^2$$

The two given values for sin30°, viz., ½ and 1719, should have been explained more fully and it should have been stated that $2\times 3.1416r = 21{,}600$ is not exact.

P. 97, l. 10 from bottom. The statement that "both the form and the spirit of the arithmetic and algebra of modern times are essentially Indian" would remain too strong even if the adjective *elementary* were used to modify these subjects.

P. 106, l. 25. There is a great difference between *assuming* that a theorem is true and *proving* it. As we have no evidence that the Arabs had actually proved that the sum of the cubes of two positive integers cannot be the cube of an integer it is questionable whether it should be said that they "discovered" this theorem.

P. 116, l. 10 from bottom. Omit the letter a.

P. 133, l. 9 from bottom. "The most difficult step" in the solution of the general cubic seems to be stated vaguely here. This solution, as all algebraic solutions, depends on changing the form of the equation so as to obtain a solution by one or more root extractions. Several obvious errors appear near the bottom of this page.

P. 134. The last lines on this page are not in complete accord with what was said before about the claims which Tartaglia may have as regards the discovery of a solution of the general cubic. This is one of many instances where the revision of the earlier edition was not sufficiently complete to accord fully with later discoveries added in the present one.

P. 135. l. 6 from bottom. "The reality of the apparently imaginary expression which a root assumes" was not fully discussed by Bombelli. It is true that he gave the oldest known example of the sum of two cube roots of complex numbers which is equal to a real number, viz.,

$$\sqrt[3]{2+\sqrt{-121}} + \sqrt[3]{2-\sqrt{-121}} = 4.$$

Cf. *Encyclopédie des Sciences Mathématiques* tome 1, vol. 1, p. 331.

P. 165, l. 27. The term roulette is commonly used with a wider meaning than the term cycloid.

P. 178, l. 1 from bottom. Descartes rule of signs does not determine the *number* of real roots.

P. 184, l. 26. The existence of similar triangles was assumed much more than 1000 years before Wallis.

P. 185, l. 10. The statement relating to the series which Wallis called hypergeometric is too vague.

P. 185, l. 15 from bottom. It is not exact to call *m* "greater than unity and negative."

P. 191, l. 18. Cf. p. 37, l. 12 from bottom.

P. 213, l. 16 from bottom. Instead of G. G. Leibniz write G. W. Leibniz.

P. 234, l. 5. Cf. p. 232, l. 4 and p. 251, l. 21.

P. 239, l. 23. Cf. L. E. Dickson, *History of the Theory of Numbers*, 1919, p. 42, where it is pointed out that Euler included two false pairs of amicable numbers.

P. 253, l. 3 from bottom. Many earlier proofs of this theorem had been attempted. Cf. *Encyclopédie des Sciences Mathématiques*, tome 1, vol. 2, p. 191.

P. 254, l. 14 from bottom. Cf. p. 239, l. 14 from bottom.

P. 265, l. 16 from bottom. The statement that "it remained for K. F. Gauss to break down the last opposition to the imaginary" seems too general. Many others participated in the general introduction of complex numbers, especially those who first established the legitimacy of these numbers by showing that the ordinary operations involving them can be interpreted by means of real quantities. Gauss was very influential in extending the use of complex numbers among German mathematicians.

P. 266, l. 19. There is no method of solving equations commonly known as "method of combination." The method referred to relates to a use of the elements of the theory of substitution groups, which Lagrange called "calcul des combinaisons." Cf. J. Pierpont, *Bulletin of the American Mathematical Society*, vol. 1 (1895), p. 197.

P. 267, l. 13 from bottom. The third edition of Legendre's *Théorie des Nombres* appeared in 1830. The first edition was published in 1798.

P. 280, l. 17. F. W. Meyer is here called editor and H. Burkhardt joint editor of the *Encyclopadie der Mathematischen Wissenschaften*. In fact, Meyer was editor of the first and the third volumes while Burkhardt was editor of the second volume. The expression "prominent as joint editor" could be more properly applied to F. Klein.

P. 282, l. 8. Write "it" in place of "them."

P. 287, l. 3. It should not be said that "synthetic geometry was first cultivated by G. Monge." Perhaps modern synthetic geometry is meant.

P. 296, l. 6. Instead of "brought" read "brought out."

P. 299, l. 13 from bottom. It should be stated what angles are meant by *a* and *b*.

P. 302, l. 16. This postulate of Euclid was not "proved" by him. Many later writers attempted to prove it.

P. 306, l. 5 from bottom. It is not customary to say groups "arose." They existed from eternity and are being found out and studied.

P. 323, l. 7 from bottom. Instead of "Peterson" write Petersen.

P. 327, l. 1. The statement that geometric elements are *mere things* does not appear clear. The term thing is quite general.

P. 327, ll. 9 and 21 from bottom. A deceased man is not usually regarded as being professor in a university. The sum of two similar triangles is not two right angles.

P. 330, l. 10. One *n* in the exponents should be replaced by *m*.

P. 331, l. 8. The first meeting of the London Mathematical Society was held on January 16, 1865.

P. 338, l. 19. The first meeting of the American Association for the Advancement of Science was held in 1848.

P. 348, l. 12 from bottom. Instead of F. W. P. Schonemann write T. Schonemann. The son's name contained the initials F.W.P.

P. 349 beginning of second paragraph. If the names of Lagrange and Argand are mentioned in connection with the proof of the fundamental theorem of algebra it should be added that many others had attempted to prove this theorem. The name of D'Alembert would seem to deserve especially to be mentioned in this connection since the theorem is often called by his name.

P. 353, l. 7 from bottom. Instead of 1861 write 1860.

P. 360, l. 14 from bottom. Write "order" instead of "degree."

P. 361, l. 21 from bottom. Write "were" instead of "was."

P. 372, l. 8 from bottom. Write 1867 instead of 1862.

P. 373, l. 12 from bottom. This is not stated clearly since the terms of a series may have a limit without attaining it ultimately. There may not be an ultimate term in the series.

P. 401, l. 15 from bottom. Instead of V. A. Lebesgue write H. Lebesgue. The former was dead before the Zermelo proof in question was published.

P. 409, l. 14. As vol. 2 appeared in 1912 and vol. 3 in 1913 they should also have been mentioned in this connection.

P. 429, l. 17. Instead of Dirichlet's principle write Thomson-Dirichlet principle as is done on the preceding page.

P. 438, l. 15. Fermat's equation can "exist" but cannot be satisfied by positive rational numbers under the given condition.

P. 444, l. 6 from the bottom. The first steps towards number fields were taken earlier. Gauss worked in this direction.

P. 487. It should have been noted that where biographical notices are given the first page number following an author's name refers to this. Hence the numbers which follow an author's name are not always arranged in order.

P. 494. Instead of "Emsh" write "Emch."

P. 501. After Kowalevski, Madame, delete the last 436.

P. 502. Insert the name of H. Lebesgue. Most of the references after the name of V. A. Lebesgue relate to the work of H. Lebesgue.

P. 503. Delete 360 after the name McClintock.

P. 505. Under the word "Number" add the number 267 after "quadratic reciprocity."

P. 507. Instead of "Peterson" write "Petersen."

The number of these marginal suggestions may appear large, especial y since it does not claim to be a complete list of desirable modifications. In view of the great variety of subjects treated and the vast amount of material which had to be considered it was only to be expected that private copies could be greatly improved by the addition of numerous marginal notes. Many of the notes here suggested can be very much abbreviated before they are entered.

SOME MATHEMATICAL HOWLERS.

Question: Substitute the roots obtained in the equation and explain the failure of some of them to satisfy the equation.

Answer: Plus or minus the square root of seven will not satisfy the equations (*sic*) for an unknown quantity equalling a radical sign will never satisfy an equation.

Question: Write down and prove the formula for the sum of n terms of the series a, $a+d$, $a+2d$, etc.

Answer 1: The formula for n terms of a series is $\frac{a}{1-r}$ or $\frac{a}{1-d}$
Since the last number in a series of n terms cannot be found, the last term must be dropped out and the sum would increase indefinitely as the terms are gradually increased.

Answer 2: $\frac{a+a+(n-1)\,d}{2} - n = S$. First, you start with the difference d, which is the progression one step. The next consideration is the number of steps and this is one less than the number of terms, to wit: $(n-1)$. Multiply $(n-1)$ by d and you get the progress. Take the progress and add it to the first term and this will carry you to the last term. Take the first term and the last term, add them together and divide by two. This will give you the average term. If this is the average for one term, multiply it by the number of terms and this will give the sum.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

616. *Proposed by Daniel Kreth, Wellman, Ia.*

A and B, 171 miles distant from each other, travel toward each other until they meet. A travels one mile the first day, two miles the second, four miles the third, etc., while B travels 20 miles the first day, 18 miles the second, 16 miles the third, etc. Assuming that each day's journey by each of them is traveled at a uniform rate of speed, where will they meet?

Solution by Norman Anning, Meaford, Ont.

In n whole days A travels (2^n-1) miles and B travels $(21n-n^2)$ miles.
When $n = 6$, $(2^n-1)+(21n-n^2) = 63+90 = 153 < 171$.
When $n = 7$, $(2^n-1)+(21n-n^2) = 127+98 = 225 > 171$.
At the end of 6 days they have still to go 18 miles. During the seventh day A travels eight times as fast as B. He will therefore go 16 miles while B is going 2. When they meet

A has gone $63+16 = 79$ miles,

B has gone $90+ 2 = 92$ miles.

Also solved by R. T. McGregor, A. Pelletier *and* Herbert C. Whittaker. One incorrect solution received.

617. *Proposed by E. Kesner, Salida, Col.*

Show that if n is any positive integer

$$2^{2n}+15n-1 \text{ is a multiple of } 9.$$

I. *Solution by the Proposer.*

$$15n-1+2^{2n} = 15n-1+(1+3)^n = 15n-1+1+3n+\frac{n(n-1)}{1\cdot 2}.3^2+$$

$$\ldots +3^n = 18n+\frac{n(n-1)}{1\cdot 2}.3^2+ \ \ldots\ldots \ +3^n$$

every term of which is a multiple of nine.

II. *Solution by A. Pelletier, Montreal, Can.*

By mathematical induction:

If the proposition be true for $n = k$ let us also prove it true for $n = k+1$, or simply for the difference between the two expressions.

The difference between $2^{2k+2}+15(k+1)-1$ (1)

and $2^{2k}+15k-1$ (2)

is $2^{2k}.3+15$, or $3(2^{2k}+5)$. (3)

Now $2^{2k}+5 = 2^{2k}+2+3 = 2(2^{2k-1}+1)+3$, which is divisible by 2^1+1, or 3; hence (3) is divisible by 9 and if (2) be divisible by 9, so will (1). For $k = 1$ and 2, (2) becomes 18 and 45; hence it is generally true.

III. *Solution by Norman Anning, Neaford, Ontario.*

$2^{2n}+15n-1 = 4^n-1+15n = 3(4^{n-1}+4^{n-2}+\ \ .\ \ .\ \ .+4^2+4+1+5n).$

The given expression is a multiple of 9 if the quantity in brackets is a multiple of 3. In the scale of four

$$4^{n-1}+4^{n-2}+\ \cdot\ \cdot\ \cdot\ +4+1$$

is expressed by n 1's in a row and the sum of its digits is n.

Now 3 stands in the same relation to the scale of four that 9 does to the scale of ten. Hence

$$4^{n-1}+4^{n-2}+\ \cdot\ \cdot\ \cdot\ +4+1-n$$

is a multiple of 3 and, adding $3\times 2n$, so also is

$$4^{n-1}+4^{n-2}+\ \cdot\ \cdot\ \cdot\ +4+1+5n.$$

Solutions were received from W. R. WARNE (2) *and the* PROPOSER, *a second solution from* A. PELLETIER *and one by the theory of numbers from* NORMAN ANNING.

618. *Proposed by Walter R. Warne, Carlisle, Pa.*

The Problem of Apollonius: Describe a circle tangent to three given circles.

[EDITOR'S NOTE: *Attention is called to the note on page 189, Vol. XIX (February 1919) introducing the first of a series of five familiar (to most of us) problems of which this is the last. Your attention is also invited to the historical note following "Philomathe's" solution.*]

I. *Solution by Arthur Pelletier (Philomathe), Montreal, Can.*

Describe a circle tangent to three given circles C, C′, C″.

Let r, r', r'' be the respective circles and O the center of the required circle.

With radius OC″ and center O, draw a circle. It is easily seen that this circle is tangent to circles $C_{r-r''}$ and $C'_{r'-r''}$ and the problem is reduced to that of number 603 already treated.

In general, each solution of number 603 will give two solutions of 618. So in all there are eight solutions. Of course there could be less, or even none at all. In the above it is supposed that r'' is the shortest radius.

This is *Viète's Solution*, which is the one generally adopted in elementary textbooks. The next solution is independent of all particular cases.

Second solution by A. Pelletier.

Construction:

Given circles C, C′, C″. Let O″ and O′ be the respective exterior centers of similitude of C, C′ and C, C″, CO″ cutting C at E and C′ at F, also CO′ cutting C at G and C′ at H. Draw circles through EF and GH and from O″ and O′ draw tangents O″T and O′T′ to these respective circles. With centers O″ and O′ draw circles TMN and T′MN having MN for common chord, or radical axis. From any point α in MN as a center draw a circle having for radius the tangent $\alpha\beta$ to circle TMN. This circle cuts C at I and J. Join IJ cutting O′O″ at m. From m draw mA tangent to C. Join CA meeting MN at x, the center of the required circle. xA is its radius.

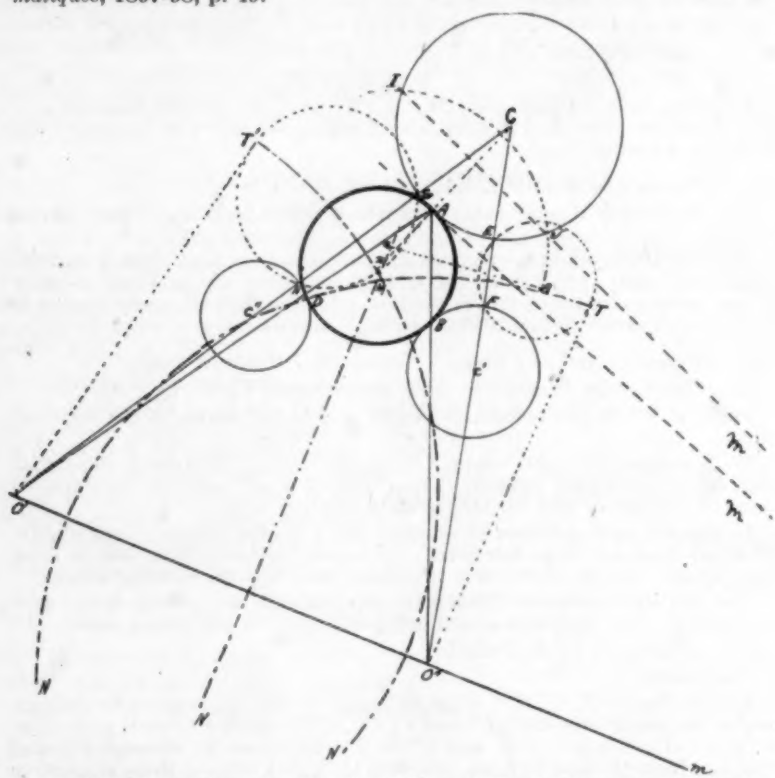
Proof:

The above construction is based on the following analysis.

Let A, B, D be the three points of contact of circle x with C, C′, C″. $\overline{O''B}\cdot\overline{O''A} = \overline{O''E}\cdot\overline{O''F} = \overline{O''T}^2$, a known quantity, also $O'A\cdot O'D = \overline{O'T'}^2$, a known quantity. Hence, center x is on MN, the radical axis of circles O′ and O″ (too long to be proved here, but see Poncelet's *Applications d'Analyse et de Gèomètrie* (Tome I). As all circles having their centers in MN and a radius tangent to TMN have the same radical axis O′O″, it explains why chord IJ and tangent at A meet at m on O′O″. The remainder is self-evident.

Historical and Bibliographical note (from the French point of view) by A. Pelletier.

This problem was treated by Apollonius in a work whose title alone was transmitted to us by Pappus. Adrianus Romanus solved it later by using conics. Then Viète gave the solution above (the first). Descartes, Newton, Euler, Poncelet, Gergonne, Bobillier, Mannheim, Fauche and Gèrard also treated the question. See *Nouvelles Annales de Mathématiques* for 1883, 1884, 1885, 1886, 1891, 1892; also Poncelet's *Traitè des propriétés projectives des figures*, page 139, and *Applications d'Analyse et de Géométrie*, Tome I, pp. 29 and 444; Gèrard, *Bulletin des Sciences mathematiques*, 1897-98, p. 49.



According to E. Lemoine (*N. A.* 1892, p. 453), the best solution as far as simplicity and exactness is concerned is that of Mannheim (*N. A.* 1885), then comes Viète's, and Fouche (*N. A.* 1892, p. 227), finally Gergonne's, though elegant and remarkable.

Gèrard gave a beautiful elementary solution. Fouche's construction lends itself very easily to the complete and simple discussion of the reality of the solutions and the nature of the contacts (see *Rouchè and Comberousse, 7th ed.*, p. 297). The same thing may be said of Mannheim's (see a note by Levy, *N. A.* 1903, p. 49).

It is to be observed that this historical problem is but a particular case of the following:

Draw a circle cutting three given circles under given angles.

Solutions were received from A. H. Gretsch (*method of conics*), R. Sciobereti *and the* Proposer.

619. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

Given three points A, B and C, to find a fourth point P such that the

areas of the triangles APB, APC, BPC shall be proportional to three lines L, M and N.

Solution by A. Pelletier, Montreal, Can.

Divide AB externally at O so that AO/BO = M/N, also divide AC internally at I, so that AI/IC = L/N; then BI and OC will meet at P, the required point. For, APC/BPC = AO/BO = M/N, and APB/BPC = AI/IC = L/N. Hence, APB : APC : BPC = L : M : N.

Also solved by NORMAN ANNING.

620. *Proposed by W. W. Gorsline, Chicago.*

In the triangle ABC $\angle A$ is three times $\angle B$. Prove

$$bc^2 = (a+b)\,(a-b)^2$$

I. *Solution by Norman Anning and E. Kesner, Salina, Col.*

$$(1).\quad \frac{\sin 3B}{a} = \frac{\sin B}{b} = \frac{\sin 4B}{c}.$$

$$\frac{a-b}{c} = \frac{\sin 3B - \sin B}{\sin 4B} = \frac{2\cos 2B \sin B}{2\cos 2B \sin 2B} = \frac{1}{2\cos B}.$$

$$\frac{a+b}{b} = \frac{\sin 3B + \sin B}{\sin B} = \frac{2\sin 2B \cos B}{\sin B} = \frac{4\cos^2 B}{1} = \left(\frac{c}{a-b}\right)^2.$$

$$bc^2 = (a+b)(a-b)^2.$$

II. *Solution by Norman Anning.*

Trisect angle A by lines meeting CB in D and E. (order – C, D, E, B.) From isosceles triangles, ACE and AEB,

$$CE = CA = b,$$

$$EA = EB = a-b.$$

Since $\triangle ADC$ is similar to $\triangle BAC$,

$$AD = bc/a,\ CD = b^2/a.$$

$$DB = CB - CD = a - b^2/a = \frac{a^2-b^2}{a}$$

Since $\triangle ADE$ is similar to $\triangle BDA$,

$$AD/AE = BD/BA,$$

$$\frac{bc/a}{a-b} = \frac{(a^2-b^2)/a}{c},$$

$$bc^2 = (a-b)(a^2-b^2) = (a+b)(a-b)^2.$$

Also Solved by A. PELLETIER (*4*), C. E. GITHENS (*2*) NORMAN ANNING (*3rd solution*), H. C. WHITAKER, LAURA GUGGENBUDLER *and* WALTER R. WARNE (4).

PROBLEMS FOR SOLUTION.

631. *Proposed by R. T. McGregor, Elk Grove, Cal.*

If $a : b = c : d$ show that $a^4d^4 - a^2b^2d^4 + b^4c^2d^2 - b^4c^4 = 0$.

632. *Proposed by Walter R. Warne, Carlisle, Pa.*

Determine k so that one root is twice the other in

$$(2k-1)x^2 + (k+3)x + (k^2-2k+1) = 9.$$

633. *Proposed by N. P. Pandya, Amreli (Kathiawad), India.*

Draw a straight line bisecting each of two coplanar triangles. Under what circumstances will its intercepts within the triangles be equal?

634. *Proposed by Herbert C. Whitaker, Philadelphia, Pa.*
Find the value of $(-\pi)^{\pi}$.

635. *Proposed by Walter R. Warne.*
Find the maximum value of $\dfrac{csc^2\theta - tan^2\theta}{cot^2\theta + tan^2\theta - 1}$.

Errata.

First Problem in November, No. 626, should read in 5th equation—e_3 instead of —e_5.

Second Problem 626 (should be 627) should read $(1+\sqrt{2})^x$ instead of $(1+\sqrt{2})x$.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

333. *Proposed by H. J. A. Hackenberg, Manager, The Cleveland Instrument Co., Cleveland, Ohio.*

Can you devise (or locate) an equation for the current in the galvanometer of a Wheatstone Bridge circuit when voltage of battery and resistance are given?

The attention of examiners is respectfully directed to the attached lists of questions.

334. Are these distant colleagues using the right or wrong kind of questions for examinations (and for school boys)?

Physics.

School Intermediate Examinations, December, 1918, and February, 1919.

The Board of Examiners, The University of Melbourne, Melbourne, Australia.

(Attempt Six Questions from Section A, and Three Questions from Section B)

Section A.

1. Define position.
   Give the specification of the position of a point:
   (a) in a straight line,
   (b) in a plane,
   (c) in space.
   Illustrate each of these three cases.
2. State the rules of addition and subtraction of directed quantities.
   A ship sailing through a current which flows in a northwesterly direction at the rate of four miles per hour, travels due east at the rate of twelve miles per hour. Determine graphically the speed and direction of the ship's own motion relative to the land.
3. Give two instances of the practical use of the following machines:
   (a) A lever.
   (b) A simple movable pulley.
   (c) An inclined plane.
   What is the advantage gained in each case?
4. State Newton's First Law of Motion, and show by reasoning from this law that a particle, moving with uniform speed in a circular path, is undergoing acceleration.

State and explain Newton's Third Law of Motion.
Give an illustration of this law.

5. Define Energy and Power.
Apply the Principle of Conservation of Energy to the following problem:
A weight hanging by a string is given a horizontal blow, which starts it off with a velocity of 400 cms. per sec. How high will it rise above its original level? (g = 980 cms. per sec. per sec.).

6. A glass U-tube is provided with an outlet from the bend of the U, which can be opened and closed by means of a clip.
The tube is inverted and placed so that one arm dips into a solution of Copper Sulphate and the other arm into water.
A part of the air is drawn out of the tube by way of the outlet, and the clip closed.
(a) Describe and account for what happens.
(b) What observations must be made in order to determine the density of the Copper Sulphate?
(c) Express the density of Copper Sulphate in terms of these observations and the density of water.

7. Given a piece of india-rubber cord about a foot long, and a box of weights, describe carefully how you would find the relation between the increase in length of the cord and the stretching force. State this relation,and show how you would represent it graphically.

8. Explain the following phenomena:
(a) Concave meniscus of water in a glass tube.
(b) Convex meniscus of mercury in a glass tube.
(c) Spherical shape of rain-drops.
(d) Rise of oil in a wick.
(e) Insects can walk on the surface of a pond.

Section B.

1. On what factors does the change of state from solid to liquid, and liquid to vapour, depend?
What two temperatures are generally fixed on thermometers, and why?
In what respects are gases better adapted for thermometric substances than liquids?

2. What is the effect of increasing the temperature of a gas which is kept under constant pressure?
Describe and give the theory of some suitable apparatus that could be used to verify your answer.

3. Trace the volume and temperature changes in a block of ice as it is heated from 5° C. to 100° C.
Why does a lake begin to freeze at the surface?

4. What is meant by Convection of Heat in a liquid?
Describe experiments to show that liquids and gases are bad conductors of heat, and that generally heat is carried through them by Convection.

School Leaving Paper, Honour Paper, The Board of Examiners.

1. A point moves with uniform speed round a circle. Draw a graph of the displacement of the projection of this point on a diameter of the circle against the time. Show clearly how the graph is obtained.

2. Define simple harmonic motion, giving examples of it.
Show that the vibration in the vertical direction of a mass of m gms. supported by a spiral spring is simple harmonic. If a force of F dynes is required to extend the spring L cms., prove that the time of vibration of the mass is: 2π ML/F seconds.

3. Define power. How is the power of an engine measured?
Express 1 horse-power in centimetre-gram-second units.
1 H. P. = 33,000 foot-pounds per minute.
1 lb. = 454 gms.
1 metre = 39.37 inches.

4. Describe fully the properties of radiant heat, stating in what respects radiant heat resembles light.

5. Describe the construction of the astronomical telescope, and give a diagram showing the path of rays forming an image in the telescope.
Defining the magnifying power of a telescope as the ratio of the angle subtended at the eye by the image to that subtended by the object, prove that the magnifying power of an astronomical telescope is equal to the ratio of the focal lengths of objective and eye-piece.
6. Describe the construction, adjustment, and use of the spectroscope.
Describe the spectrum of (a) the sun, (b) a sodium flame, (c) light transmitted through a sheet of colored glass or other absorbing medium.
7. What is meant by resonance?
A tuning-fork causes resonance in a pipe one foot long and closed at one end. The velocity of sound in air is 1,100 feet per second. What is the pitch of the fork? Give full reasons for your answer.

SOLUTIONS AND ANSWERS.

328. *Proposed to boys in The Warner & Swasey Apprentice School by Mr. Worcester R. Warner.*

The Panama Canal Locks at Gatun are in a series of three, each 1,000 feet long and 110 feet wide. Each of the three locks raises or lowers a ship 28 feet.

Gatun Lake is, therefore, 84 feet above sea level.

It is desired, first, to determine the quantity of water required to take each ship—one at a time—from the Caribbean Sea into Gatun Lake; and, second, the quantity of water required to return each ship—one at a time—from the lake to the Caribbean Sea again.

Answers are required in tons, computed by the following formula:

Cubic feet of water X .028 = tons.

Let us suppose a ship has just come down from Gatun Lake to the Caribbean Sea. The ships "A" and "B" are waiting to be taken from the sea to Gatun Lake, and back to the sea again, "B" to follow "A" in each direction.

Question 1: How much water must be taken from the lake to take "A" from the sea into the lake?

Question 2: How much water must be taken from the lake to take "B" from the sea into the lake?

Question 3: How much water must be taken from the lake to take "A" from the lake to the sea?

Question 4: How much water must be taken from the lake to take "B" from the lake to the sea?

The displacement of these ships is 35,000 tons each.

What is the correct answer?

What is the Correct Answer?

The *Editor* has received a number of answers to this problem. The answers, as is seen, are quite inconsistent

What is the matter?

Are not these questions plainly put?

Are they not practical?

This problem appears exceedingly simple. Is the trouble with our thinking processes?

Try it out in your classes and submit the results.

Solution Number 1. Please criticize.

Locks measure 1000′ L x 100′ W×28′ D.

Cubical contents, 1000 x 110 x 28 =3,080,000.

Weight of water in tons, =2,800,000 x .028 = 86,240 tons.

Locks are numbered from 1 to 3, starting from sea level.

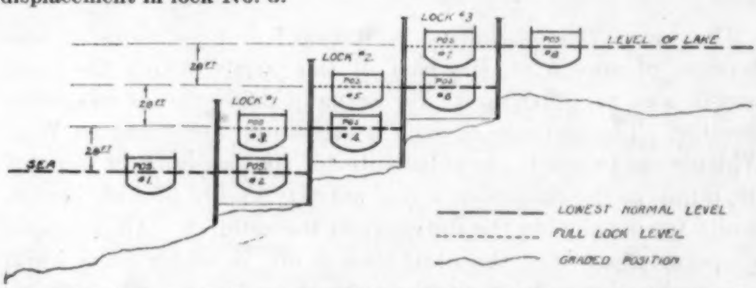
When ship A enters lock No. 1 going into lake it displaces its own weight in water ,which is 35,000 tons. Lock is then filled to its normal level, which requires 86,240 tons of water, but when lock is open and ship sails into next lock the water displaced in lock No. 2 will rush back into

No. 1. Then, the total amount of water used to fill lock No. 1 is 86,240 T + 35,000 T = 121,240 tons.

The total amount of water used to fill lock No. 2 is the same, or 121,-240 tons. The total amount of water used to fill lock No. 3 is the same, or 121,240 tons. Total amount of water drawn from lake to take ship A from sea to lake is 363,720 tons.

When ship B is ready to sail to lake all three locks are filled.

Lock No. 1 is emptied into sea and ship enters; it is then closed and water from lock No. 2 is used to fill No. 1. Ship B enters lock No. 2 and water from lock No. 3 is used to fill up lock No. 2. Ship enters lock No. 3 and the amount of water drawn from lake is 86,240 tons. After ship B enters lake 35,000 tons of water from lake will rush in to fill dis-displacement in lock No. 3.



The total amount of water used to sail ship B from sea to lake is 86,-240 tons + 35,000 tons = 121,240 tons.

When ship A is ready to sail down to sea all three locks are filled.

Ship A enters lock No. 3.

Water from lock No. 1 is let out into sea.

Water from lock No. 2 is let out into lock No. 1.

Water from lock No. 3 is let out into lock No. 2. and ship sails into lock No. 2.

Water from lock No. 2 is let out into lock No. 1 and ship sails into lock No. 1.

Water from lock No. 1 is let out into lake and ship is now at sea level.

In taking ship A down to sea level all three locks were filled, therefore, it did not require any water to be drawn from lake.

When ship B is ready to sail from lake into sea, all three locks are empty. Lock No. 3 is filled to normal. Amount of water drawn from lake is 78,400 tons. When ship B enters lock No. 3 it displaces 35,000 tons of water which is forced into sea. Lock No. 3 then contains 86,240 tons—35,000 tons = 51,240 tons.

Water from lock No. 3 is let out into lock No. 2, ship then sails into lock No. 2.

Water from lock No. 2 is let out into lock No. 1, ship then sails into lock No. 1.

Water from lock No. 1 is let out into sea and ship B is then at sea level.

Water required to sail ship from lake into sea is 51,240 tons

Solution Number 2. Please criticize.

Capacity of Lock, 28 x 110 x 1000 x .028 = 86,240 T.
Displacement of A = 35,000 T.

Weight of H_2O needed No. 2 to No. 3 = 51,240 T.
3 x 51,240 = 153,720
add displacement No. 7 to No. 8 = 35,000

Total to get A up = 188,720 tons.

To get B up let out 86,240 tons from first lock and this much more will be needed—B up = 86,240 tons.

To get A down no more water will be needed—A down = 0.

To get B down the capacity of lock is needed—86,240 tons.

THE SOCIALIZED RECITATION IN MATHEMATICS.

By F. E. Buss,
High School, Madison, Wis.

During the last two or three years the socialized recitation has been the subject of many a conversation of worthy pedagogues and enthusiastic teachers, so much so in fact that a teacher with but a normal interest in his work could not help being curious about it, as to what it really is and why it should be.

The term, "the socialized recitation," implies more or less freedom of speech on the part of the pupils during the class period, also an opportunity for actually doing things whenever possible. The purpose of such a recitation, according to Wm. Whitney, is twofold: to substitute for the passivity of most of the pupils in the classroom actual activity and to provide opportunity for developing the initiative of the children. All teachers, of course, agree that the ideal class is one in which every child is actually thinking about the subject under discussion every minute of the time. If the pupils are given an opportunity to voice their thoughts and are even encouraged to do so, there naturally is an added incentive for thinking about the subject. If the other members of the class express their opinions, each individual desires to do likewise, hence tries doubly hard to have an opinion. In recent years, initiative on the part of an individual seems to have been a growing factor in his struggle for success. Thus far it has been an incidental or accidental result of our teaching. But the socialized recitation recognizes its worth and provides for its development.

Now, how manipulate a socialized recitation? It is very evident that by permitting and encouraging this greater freedom, utter confusion might easily result. The teacher must have a very definite plan in mind, must outline it to the pupils and make the necessary regulations to achieve his aim. The actual method of procedure may vary, but the usual tendency of teachers who have tried out the socialized recitation is to have the class work in groups. The number in a group may vary from two to six and the groups may be arranged so that poor students form one group, those of moderate ability another, etc.; or each group may contain an excellent student as leader, a few mediocre ones, and one or two poor ones. Still other teachers who favor the group plan, arrange these groups with no thought of their rank as students, but from the point of view of getting together

those that will work well as a group. Groups may be broken up and rearranged daily or whenever the teacher sees fit. They usually work as units in different parts of the room, but may be called together for a class recitation or a group report to the class, for a whole period or part of one at any time. When a group reports to a class, its leader may do the talking, or he may call on one of his co-workers to do so, while the others will fill in his recitation. The rest of the class may ask questions, criticize, etc., being called on by the group leader or by the pupil reciting.

The other plan of the socialized recitation which has usually found favor is the one according to which the class conducts itself. A leader is usually appointed by the teacher for the period or part of it, to open the discussion, call on others to contribute information, to correct, to criticize, or to question; or the members of the class may volunteer. The danger, in the latter case, of course, is a monopoly of the recitation by capable people to the exclusion of the weaker ones. This the leader must guard against. Both this method and the group plan depend for their success on the fact that the pupils recognize their responsibility; that it is their duty not only to keep things going, but to work towards some end and thus cover a certain amount of ground in the recitation. True, the teacher, as a member of the class, can step in whenever he chooses, but he naturally considers himself most successful when it is unnecessary. This leads to the question as to whether one should have the socialized recitation in every class. I should say, "No." Sometimes it happens that a class group is entirely lacking in leaders, in the kind of pupils who recognize what they are working toward and make an effort to attain that end. In such a class a socialized recitation would fail utterly. Any kind would, except one in which the teacher directs the class constantly. Sometimes, too, a teacher, through no apparent fault of his own, fails to instill into his class a desirable class spirit. Under such circumstances, the socialized recitation would hardly be successful, for class spirit, the desire to accomplish, to make and not to mar, is more essential to the socialized recitation than to any other.

Now, to what extent can we use the socialized recitation in mathematics? Is it feasible to have socialized recitations every day, or shall we have them only occasionally? Shall we use the group or the class method? And, if we socialize, how best shall we begin? As yet we have few records of what has been done in

socialized mathematics recitations. To me it seems that in so far as there are certain principles to be taught in algebra, we can reasonably expect that there must be a certain number of lessons which must be developed by the teacher with the cooperation of the pupils, rather than to be worked out by the pupils alone, but that for a large amount of drill work, the group form of the socialized recitation is decidedly advantageous.

In my algebra classes I have made use of the group form of recitation both for drill on mechanical processes, as for example, addition and subtraction of fractions, and in solving concrete problems. The number in a group varied from two to five, one member of the group usually working at the board, the others sometimes standing by to assist, or following the work at their seats. Each group usually had its own exercises. For mechanical work, when a process had just been taught, I liked having two in a group, thus giving half of the class opportunity for immediate practice, the other half, occasion to get the method a little more firmly fixed in mind before attempting the work themselves. Then, if the pupil working became confused, his partner could help him, giving any necessary explanation. The pupils took turns in working at the board, so that as far as possible there was an equal division of labor, although when a strong and a weak pupil were linked together, the give and take adjusted itself along natural lines.

For giving weak pupils a bit of extra drill, the socialized recitation is particularly useful. Then I have just as many groups as there are weak pupils, with one of the latter in each group. The weak pupils are the board workers for their respective groups, the others remaining seated to watch them. The first one to note an error or a standstill on the part of his board worker goes to him with the necessary explanation. The pupil working corrects his error. Anyone in the group may ask the worker any question concerning his work. Such a recitation may be criticized as wasteful of time for the capable pupil and the criticism would be just if a great deal of time were spent this way. But for an occasional fifteen minutes it has its good points. Short cuts are sometimes explained that would otherwise never be mentioned. Then, too, the pupils see that there is more than one way of doing a certain piece of work.

This is especially brought out in working concrete problems. For example, when the leader of one group wrote his opening statement, "Let L represent the larger number," some of the

group objected, saying it should be, "Let S represent the smaller number." But after the problem had been solved both ways, the members of the group were ready to readjust their thoughts to the leader's opening statement, even if they would have begun the other way. In solving concrete problems, however, group work has a disadvantage. Pupils do point out errors and try to show why they are errors, and they give the correct forms, but they fail to ask the reconstructive questions which help to set the mistaken pupils right. The teacher in supervising the work has not time to do this for every group, hence more often such questions are omitted. For concrete problems I ordinarily prefer a class recitation with plenty of free discussion by the pupils, but under the immediate direction of the teacher (hence not a strictly socialized recitation). Into such a recitation many of the good points of the socialized recitation may be introduced, such as board work with explanation of steps by one pupil, correction of his work with reasons for the change by another, another possibility of solution mentioned by a third, etc., so that everybody is constantly on the *qui vive*, but instead of having the discussion between pupils, the teacher is the intermediary between them.

In geometry as well as in algebra there will be many entire lessons or parts of lessons for which it seems advisable for the teacher to direct the class, to develop the proof of the theorem with the aid of the pupil, rather than to let them stumble around aimlessly for a while, thus wasting precious class time, just because the recitation is to be socialized. This is as bad on the one extreme as to assign the next proposition, let the class memorize the proof from the book and recite it verbatim the next day, is on the other. But for drill or review work especially, after a class has been well trained in the fundamentals of geometry, group work, with five or six in a group does make for efficiency. If a class of twenty-five is divided into five groups, there will be five recitations in progress in different parts of the room. The leader of the group may be given the advantage of reciting when he chooses, and calling on the other members at other times. All members should be ready to continue, to commend, or to find fault with the previous recitation. Should a whole group be unable to continue, the teacher may be called on as a last resort. But the obvious advantages are there, the pupil has five times as many opportunities to recite; he is less timid before his group than before the whole class plus the teacher; he does not

resent criticism, because everybody in the group gets his share.

For easy originals the group recitation is also good; for more difficult ones, I like to have the class as a whole in a socialized recitation. We need all the minds, then, concentrated on the same task in order to make headway. The pupils begin work at their seats. When the first member thinks that he has a solution he goes to the board, draws the figure, calls the class to attention, and proceeds with his proof. As soon as there is a flaw, hands go up, and he calls for information. If the flaw throws out his proof, another may begin or continue with the work. Should every one be on the incorrect track, the teacher, as a member of the group may give a suggestion.

In both algebra and geometry, then, the socialized recitation may be used to advantage at times, either for an entire period or for a part of it; either in the class or group form. But frequently throughout the year and continually for a time during the beginning of the year, lessons in which the subject matter is developed under the direction of the teacher are necessary. The pupils like the socialized recitation, for it gives them power and self-reliance; they like to talk directly to each other; they like to feel that they can explain things so that their classmates can understand them; and they develop an unusual keenness in criticism. The older the students, of course, the greater is their sense of responsibility, and the greater will be the success of the method.

CLASS ROOM SAYINGS.

Why does an aeroplane rise?

"An aeroplane rises because of the action of its wings beating upon the air. It is lighter than the air, and thus it may (to speak unscientifically) place its wings upon a layer of air, and by leverage raise itself to a higher position, in precisely the same manner as a bird flies."

Define volt, ampere, ohm.

"A volt is the electromotive force that will carry a current through a distance of one ampere with a resistance of one ohm."

"An ampere is a volt flowing through one ohm per second."

"An ohm is the quantity of resistance against one volt flowing at the rate of one ampere per second."

(The above answers were collected from tests given to first-year students in a university in a required course.)

Of what are clouds composed?

"Liquid air."

"I don't know what an East Indian Typhoon is, but there is only one in captivity."

"If a ray of white light is passed through a glass prism there will be seen all the colors of the solar rectum."

STANDARDIZED TESTS IN SCIENCE.[1]

By Ralph E. Wager,

Normal School, De Kalb, Ill.

The changes now taking place in the field of educational thought compel attention. It will be unnecessary for me, as an introduction to our problem, to do more than call to your minds the fact that the decay of the doctrine of formal discipline is making necessary a readjustment in practically all our educational attitudes. And this is true in fields other than that of science, for all subjects alike are being reformed according to new patterns; and these patterns are, in outline at least, in conformity with certain well defined concepts. Let me push this idea a little further.

For decades the formal and more or less abstract type of materials with which our science teaching dealt was justified by the argument that it "trained the mind." When James, years ago, suggested that the validity of the theory be tested out, he set in motion a current which has pretty thoroughly eroded the old educational landmarks, and we are now compelled to justify our procedure and our product on entirely different bases. What are these new patterns and where are the new landmarks?

In answer to this question let us review briefly the relatively recent movements in so far as our own subjects are involved.

You will recall that botany as well as zoology found its origin in the natural history of plants and animals. This period was a long one in human evolution, and was followed, beginning about two centuries ago, by the effort to bring order out of the chaotic nomenclature accumulated, by the period which may be characterized as that of taxonomy. This in turn developed into another somewhat less distinct though very active movement toward morphology and physiology. Out of this latter by a return to the original natural history attitude has developed the dynamic interpretation of the present time.

Now it was only natural that the materials which were occupying the thought of those who were devoting their lives to the development of these subjects should find their way into the textbooks used in the schools. Not to return to history too far removed, an examination of the books used within the past forty years will reveal the characteristics of at least the last

---

[1]Read before the Biology Section of the Conference of the University of Chicago with its affiliated schools, May 9, 1919.

three periods. It was only to be expected that many of the discoveries in the fields of botany and zoology, as well as physiology, were finding applications in meeting the problems of man's existence. Hence there was a gradual introduction of these useful discoveries into the textbooks. One finds, for example, that a decade ago the botany books, written for high school use, were made to include a large percentage of applications of botanical facts in such forms as principles of forestry, plant breeding, plant propagation, and similar so-called practical applications. This was true also in the case of zoology although to a lesser extent. At the same time physiology was changing its center of gravity from pure anatomy and morphology to hygiene, with the emphasis upon the personal aspects. Now then, what were the outcomes?

It is impossible to answer this question in more than a very indifferent way, because there were no standards perfected by which to measure them. If we may attempt to judge, however, by those which we are now trying to use, it seems entirely within the bounds of truth to characterize them somewhat in this way: In the first place, they were almost entirely apart from the everyday problems of life; by that I mean that the facts learned were not applied in any way and hence lacked the essential quality of reality. They existed for the pupil only in the book. In the second place, their disciplinary values were often questionable, since in the majority of cases the teaching was poor, consisting of memoriter work, with little or no effort at developing real situations comparable or identical with those in actual life together with the power to cope with them. The laboratory furnished a place for verifying the statements of the book or outline, and not a place for developing genuine powers in scientific procedures. The imparting of information was, and for that matter too often still is, the only conscious aim in much of the teaching. The outcomes, therefore, were of little value in so far as was concerned the influencing of the inner life of the pupil and his capacity to meet more successfully the everyday life problems.

Against this formal and frequently useless type of instruction there was certain to be a revolt. It manifested itself in the introduction of agriculture and all the other arts and vocational trainings, their protagonists claiming that disciplinary values might be had as well in the doing of something worth while as in the useless, and at the same time make some definite prep-

aration for the art of living. Thence arose the project: an effort to place before the pupil an actual life situation and to guide him in its solution as one problem after another presents itself. Of course there then emerged the question of the relative values of various types of projects, and to it a fairly definite answer has been made, for above all other criteria by which values are to be placed is that of social worth. Outcomes are to be considered justifiable only as they give power to meet conditions in human society in a practical, efficient manner; not losing sight of the fact, of course, that such adjustments mean giving as well as getting.

I cannot refrain from continuing this apparent digression to note also that another reaction manifested itself, and resulted in the introduction of General Science. So far was the current elementary or high school science removed from the everyday problems of living that the outcomes were placed under heavy suspicion as to their usefulness. Then began the movement to take simple elements out of life and find their scientific interpretation, choice being determined again by the criterion of commonness and practicability. Now undoubtedly this lay in the right direction, but one is compelled to admit that up to the present time there has appeared no consensus of opinion as to what the course should yield in the way of generalized outcomes nor any approach to a unanimity of belief as to what materials may most efficiently serve the purpose. Indeed, one is amazed at the heterogeneity of the aims, and the still greater diversity of materials. It would seem that for the sake of efficiency in teaching there ought soon to develop an agreement on at least the fundamental aim, even though such agreement may not immediately be carried over to materials. I shall revert to this topic again, but before leaving it let me call attention to the fact that the declared effort has been to make the common things of life the subject materials: to make the environmental factors understandable in at least an elementary way. And you will note that this again is an emphasis upon the social significance of the outcomes

Thus far I have taken liberties with your patience for I have not as yet suggested my arguments. It has seemed essential to call to your minds the foregoing ideas in order that the following propositions might be submitted as substantially as those with which we must deal in outlining our present problem. These are submitted as logical developments from the educational

movements so briefly outlined above; they are that:

I. The general science movement will develop further until it displaces the present first year high school botany or zoology.

II. The Junior High school may be regarded as a permanent element in our educational system.

III. The method of teaching by projects (and problems) may be looked upon as having found a permanent place as an instructional device, and to have demonstrated its superiority over the old methods.

IV. Agriculture may be expected to increase its vogue and to change more completely from simple textbook to project method of instruction. The same may be said of other related arts, such as household economics.

V. Botany, zoology and even human physiology must be radically changed, both as to content and method, in order to meet these new conditions.

If you agree with me in these propositions, you will at once see that our immediate problem is threefold: to make adjustments to the new standards in aim, content, and method. To these points, then, let us turn attention.

The arguments for the desirability of definite aims have already been presented to you, and I am restating some of them only in the hope that you may be stimulated to react and formulate yours. That we have not had clearcut aims I am disposed to believe, for if one tests out the pupils who pass through our classes, he will find a wonderful diversity of results, even on the most essential portions of the content, all of which suggests a lack of knowledge and agreement as to the points for emphasis and drill. Thus, for example, a few days ago I gave to a class, all high school graduates, a brief questionnaire, calling chiefly first, for a statement concerning the most fundamental idea or principle concerning living things obtained from their study of high school zoology, and secondly, for their attitude toward the subject as to whether they enjoyed it or not. Of the twenty replies to the first question a distribution as follows is extremely suggestive:

No. of Pupils

4—The idea that living things are adapted to their environment.
3—The idea of the survival of the fittest.
1—The idea of progressive evolution.
3—Thought that they were made more observant of Nature.
2—Most important recollection concerned the economic relations of insects to man.

2—Better understanding of economic relations of animals to man.
1—Not much remembered; possibly a better understanding of the relations of living things.
1—No effect now noted; dislikes it, and still does.
1—Not much recalled. Studied one insect, had one field trip, and the drawings were made from a book.
1—Little recollection. Subject meant little. Liked it, however. No field work, and drawings made from the book or blackboard.

On the second element, all but one of the students reported that they liked the subject.

From a review of these reports, so few in number as to be only suggestive, it is obvious that the teachers of the classes in which these young people spent their time had no definitely and clearly defined idea as to the high points in the subject. Evidently no drills were given to fix fundamental notions nor any extensive associations stimulated so that they might be long remembered. And I have a suspicion that if any considerable number of high school students were to be surveyed in this manner an astonishing condition would be discovered. It is of prime importance, therefore, that we set up clearly and definitely the results desired. With outstanding aims in mind such diverse and indefinite results were impossible.

Now merely to illustrate what I mean, and possibly also to stimulate you to organize your own ideas in the matter, let me outline what I now believe to be a rational set of definite points in such a statement of aims. For the subject of zoology I would group them under three headings: utilitarian, habits, and ideals. This is very indefinite yet, so I shall expand each in this fashion:

1. Utilitarian: (a) A knowledge of environment as related to the commoner forms of animal or plant life. The natural history of such forms. This is essential to (b) A knowledge of the relations which the more important bear to man's welfare, together with methods of control of detrimental forms and fostering of beneficent ones. (c) An introduction into the elements of morphology; sufficient to serve as a basis for some fundamental physiological concepts.

II. Habits: (a) The development of a habit of observation of objects in Nature. Storing of the mind with as many experiences as possible which shall make such observations meaningful. (b) The development of a scientific attitude; a habit of withholding judgment until evidence is at hand. This leads to (c) Development and training in the power to draw conclusions from observed data. Evaluation.

III. Ideals: (a) The development of a respect for Nature and her ways. Such as shall carry over into life, affecting the emotions, setting ideals and determining actions. (b) Contact with some of the large ideas which for the most part have evolved from biological studies, and which have distinctly stimulating and ideal-setting values. Such as: 1. The idea of progressive evolution; 2. The fundamental ideas concerning heredity together with at least a few of its personal and social applications. A basis for instruction in sex hygiene, (these ideas of course to be adapted to the social and intellectual level of the child).

If emphasis were to be placed upon this statement at any one

point, it should be, I confess, on that of habit formation. Surely no time in life is so suited to the determination and building of a mental set or attitude as is that of early adolescence, and it is the mental set which reflects itself in life situations. It is a force in conduct. By this interpretation, habits and ideals very closely approximate and then narrow still further the breadth of our aim and finally, in this connection, let it be understood that in the evolution of such habits and ideals contact with worth-while material is as readily made as with that of less significance in life. It is to determine just what is the most worth-while material that forms a part of our problem.

Having set up an aim, we may now proceed to the second point, namely, the content of the course of study. This involves no little thought if we are to be controlled at all by the conditions I have pointed out as confronting us. In the first place we must eliminate the useless materials. We must find subject matter which is vitally interesting, socially significant, and adapted to the intellectual development of the pupil. Furthermore, we must find materials suitable for project teaching, and these, too, must be significant, with definitely desirable outcomes. I have been impressed frequently with the relative insignificance of many so-called projects. In not a few cases it seems that they are essentially like the "busy work" of the lower grades in that they serve to keep pupils engaged and therefore out of mischief. Projects should have clearcut values, with well defined problems in them, and be worth while. Undoubtedly they should be standardized as to time and credit.

There is still another important aspect of this part of our problem to which attention should be called. We must examine with care other courses within the curriculum and determine what if any elements are common to both, or if any may be determined upon as essentially fundamental, and these should be incorporated. There is in both botany and zoology much that is thus highly significant as basal to agriculture and household arts, and, in the same way, much could be put into the general science basal to both botany and zoology. One meets here, however, a serious difficulty for in most cases these courses are presented (or at least no sequence is provided for) without the one taking precedence over the other. Economy of time demands a better organization. A heterogeneity of preparations makes necessary the repetition of teachings thereby prolonging the time required to bring classes to a common starting point.

Were the foundational ideas for scientific instruction as well defined and determined as, for example, are those of mathematics in the fundamental processes, such conditions could not so often exist. Then, too, in this connection also, let me urge you to contemplate the amazing assumptions made on the part of textbook writers. Elementary books on agriculture assume a knowledge of chemistry and physics and botany; physiologies assume a knowledge of chemistry. Assumptions are made all along the line. Herein, to revert to it again, I see the possibilities of the general science. Surely, there must be a few principles somewhere between the ion and the milky-way which might be agreed upon as basal to any science, and which could be presented with care and drilled upon until something approaching the automatic responses for the four fundamental arithmetic processes would follow.

I have mentioned the Junior High school as a factor in the problem. It seems to me that we should seek to have incorporated in the first and second year of the Junior High school some considerable science of a distinctly foundational nature. This means materials selected with a view to its bearings upon future problems. Let this be taught with as great care as any other subject. I am not unmindful of the Nature-Study work as it is carried on in some schools, but this too lacks definiteness. There is needed a realization of the fact that a certain result is sought, a definite, clearcut, and attainable aim, and along with that, a reasonable standardization of materials and content. A few problems well attacked and attended with suitable drills is certainly more desirable than a scattering over a wide field with indefinite results. Here is opportunity for really constructive education. Already the general science is being tried out in special classes in the seventh grade with reported success. The present situation demands, undoubtedly, a reconstruction all along the line in order to keep pace with the rapidly changing conditions in the field of elementary education. Although as high school instructors we are not directly responsible for the work done in the elementary grades, we can at least render a service in stressing the needs and pointing out the direction in which the movement must take place.

Now it may be that we shall have to return to some of our older forms of thinking. The question arises so frequently in the mind of one dealing with high school boys and girls: "Have they had any suitable foundation in their life experiences for

the work being given them, so that it has meaning and significance?" It is the answer to such a question which gives such profound impetus to the agriculture and household arts; these deal with real life-problems. How much of our botany and zoology, or even physiology, have such life-relations? Indeed, few of our boys and girls, unless happily reared upon a farm, and even then only indifferently, have any intimacy whatever with the plants and animals of their environment. As an illustration of what I mean, let me site the following: A friend not long ago sent into our laboratory a woodchuck. Placing it in a small wire cage, it was then put upon the table before the class about to enter. Each member was given a slip of paper and instructed to write upon it what he thought the animal in the cage to be. He was allowed to examine it with as much care as he desired, but not allowed to consult others about it. The results:

No. of Pupils.
- 6—No idea at all as to what it is.
- 19—A woodchuck.
- 5—A raccoon.
- 15—A muskrat.
- 2—A chipmunk.
- 1—A weasel.
- 1—A beaver.
- 6—An opossum.
- 1—A skunk.
- 1—A ground squirrel.
- 1—A squirrel.
- 1—A mink.

A similar test with a muskrat gave even more interesting results. Try out our boys and girls on any of the common plants or animals, and a profound ignorance is commonly revealed. Now the natural history aspect of science is fundamental as a suitable background for any of the more technical, and may it not be that we should return to it at least in a sufficient measure to give significance to later work? Should we not have traveling museums, carefully planned and executed field excursions, lasting, perhaps, several days instead of the usual period or two? Not only would such excursions yield the background to which I have referred, but at the same time they could be made to contribute largely to physical geography, history, industrial relations, and to foster health and self-reliance. And the Junior High school is offering the opportunity. It is the period when the spirit of adventure is strong. Shall we not, then, undertake to establish genuine science work in it? We must not make the mistake, however, of simply taking a chunk out of some

high school or college textbook and carrying it down into the seventh or eighth grades, but must find suitable materials, adapted to the instincts and interests of the pupils concerned.

It is obvious, then, that valuable work is to be done in the reorganization of the content of our courses.

(*To be continued*)

DEEPEST WELLS IN THE WORLD.

Two Deepest Wells in the World are in the United States.

During the last few years the Hope Natural Gas Company and the Peoples Natural Gas Company, both of Pittsburgh, Pa., have been drilling deep wells in Northern West Virginia and southwestern Pennsylvania to find deeper oil-bearing and gas-bearing sands, their object being to reach, if possible, the horizon of the rich Clinton sand of Ohio, which, according to Dr. I. C. White, the State geologist of West Virginia, should be found in this region at depths between 7,000 and 8,000 feet.

Drilling for Deep Oil and Gas.

The first exceptionally deep well thus drilled, the R. A. Geary well, of the People's Natural Gas Company, is about 4 miles northwest of McDonald, Pa., and about 20 miles southwest of Pittsburgh. The mouth of the well is about 1,050 feet above sea level. The well penetrates the Gordon stray sand, the last of the usual gas sands in this region, at a depth of 1,971 feet. From this point to a depth of 6,700 feet the strata penetrated are alternately "lime" and "slate," and from 6,700 feet to the bottom, 7,248 feet, they are "sand" and "lime" interspersed with about 60 feet of rock salt. The second deep well was drilled by the Hope Natural Gas Company on the farm of M. O. Goff, about 8 miles northeast of Clarksburg, in northern West Virginia. Its mouth is 1,164 feet above sea level. The well begins 200 feet below the level of the Pittsburgh coal and penetrates the usual oil-bearing and gas-bearing sands, the lowest being the Bayard, which lies at a depth of 2,210 feet. The strata in the remainder of the well are alternately "lime" and "slate." The third deep well, the J. H. Lake, of the Hope Natural Gas Company, is about 8 miles southeast of Fairmont, W. Va. It is about 20 miles north of the Goff well and about 60 miles south of the Geary well. The mouth of the well is about 1,300 feet above sea level. The Bayard sand, the lowest of the gas sands, was found in this well at a depth of 2,050 feet. The remaining strata are alternately "lime," "slate," and "sand."

Four Deepest Wells in the World.

Named in order of depth, the four deepest wells in the world are the Lake, 7,579 feet; the Goff, 7,386; a well at Czuchow, Germany, 7,348; and the Geary, 7,248. The two deepest wells in the world are therefore the Lake and the Goff, the Lake surpassing the German well by the large margin of 231 feet. In comparison with these great depths, other depths reached by wells or mines sunk in the crust of the earth are rather insignificant. The deepest mine in the world is shaft No. 3 of the Tamarack mine, in Houghton County, Mich., which has reached a depth of 5,200 feet. Other shafts of the Tamarack Company and of the Calumet & Hecla mine, in the Lake Superior region, reach depths between 4,000 and 5,000 feet. Three shafts in the Prizbram silver mines, in Austria, have reached depths of about 3,300 feet. The Victoria quartz mine, at

Bendigo, Australia, is 4,300 feet deep. A number of shafts in the Transvaal gold region of South Africa have been sunk to depths of about 4,000 feet.

Limits to Depths of Mines and Wells.

The depth to which a mining shaft can be sunk is limited by the heat of the rocks, as the temperature at a depth of a mile in nearly all parts of the earth is so high that workmen can not live in it, even with ventilation. The depth to which a well 6 inches in diameter can be drilled seems to depend chiefly on skill in drilling and strength of cable. The cable itself is heavy, and besides carrying its own weight and the weight of a drill, which weighs 1 or 2 tons, it must bear strains produced by vertical movements of the drill, which may be so great as to break it at any moment, so that the drill and a part of the cable may be lodged in the well in such a way that they can not be removed. Exceptional skill is required, therefore, in operating the ponderous machinery used in drilling a well. The drill, which is a column of steel about 5 inches in diameter and 40 or 50 feet long, beveled to a V-shaped edge at the lower end, is attached to one end of the cable, and at some other point, determined by the driller, the cable is attached to a long beam, which is operated in the same manner as the walking beam of a steamboat. Merely to lift the drill through the height determined by the swing of the end of the walking beam and to let it drop repeatedly would do no drilling. In order to drill, oscillations must be induced in the cable, such as those set up by attaching a light weight to a suspended rubber band. A slight oscillation properly induced by the finger at the upper end of the rubber band will produce a very large oscillation of the weight attached to its lower end. In some such way as this the skillful driller produces oscillations in the drill bit, which throw the sharp beveled edge of the drill on to the rock with high velocity. The only means that the driller has of knowing the behavior of the drill is the general behavior of the machinery and the slight impulses or tremors in the cable, which he detects by his hand alone.

What's in the Interior of the Earth?

The materials and the conditions in the interior of the earth have long been a favorite subject of speculation among scientific men. According to the modern mathematical theory of the propagation of earthquake waves through the earth the outer rocky shell of the earth, which is about two and one-half times as heavy as water, extends to a depth of less than 1,000 miles. Inside of this shell is some material, probably metallic, which is more than five times as heavy as water. Estimates of the temperature at the center of this nucleus range from 3,000° to 180,000° F., but these figures have little or no value, for mathematicians have not yet found the law of the distribution of temperature from the surface to the center of the earth. The temperature evidently increases with the depth, a fact again confirmed by an elaborate series of observations of temperature made in each of the three deep wells, the Geary, the Goff, and the Lake, by C. E. Van Orstrand, of the United States Geological Survey, Department of the Interior. In each of these wells the temperature at a depth of 100 feet is about 55° F. and gradually rises with increase in depth, reaching 142.0° F. in the Geary well at a depth of 6,100 feet, 159.3° F. in the Goff well at a depth of 7,310 feet, and 168.6° F. in the Lake well at a depth of 7,500 feet. The observation at a depth of 7,500 feet in the Lake well was made at the deepest point yet reached by any observer.

Some Interesting Results of Deep Drilling.

The strata of lime, slate, and sand penetrated by these deep wells were originally sediments deposited from ocean water. A bed of ocean water was actually found in the Geary well at a depth of 6,260 feet. Dr. I. C. White, State Geologist of West Virginia, with whom the United States Geological Survey is cooperating in these investigations, is of the opinion that this water is a fossil ocean, imprisoned since mid-Paleozoic time. Interesting evidence in regard to the geologic history of the formations was obtained by Charles Butts, of the United States Geological Survey, who identified a number of fossils from depths of 7,187 to 7,355 feet in the Goff well. The material from the Lake well has not yet been fully examined. It may be possible by examining the fossils to determine the geologic ages and horizons of the beds penetrated and so to estimate the depth at which the Clinton sand should lie beneath the bottom of this well. The well probably does not pass through more than one-half the total thickness of sediments in this region.

SOLAR HALOS OBSERVED AT TEE HARBOR, ALASKA.

An unusually striking formation of solar halos occurred at Tee Harbor, Alaska, on June 9, 1919. A report of these halos has been sent by Mr. W. E. Freeman. The halos occurred at about eight o'clock in the evening while the sky was almost clear. They consisted of two concentric circles, the sun being at the centre. At the highest point of the inner circle, two brilliant arches that appeared like wings extended symmetrically to the north and to the south. Tangent to the outer circle at its highest point was an inverted arc showing very distinctly the colors of the rainbow. The two points on opposite sides of the sun, usually referred to as "sundogs," were unusually brilliant, so much so, according to the report, that some people could hardly distinguish which was the real sun.—*Popular Astronomy.*

TEACHING APPLIED SCIENCE.

By Dean C. A. Adams,

Harvard University.

It is safe to say that most of the rapid strides or the long strides which have been made as the result of research—it doesn't make any difference whether you call it engineering research or scientific research; there is no line between them just as there is no line between pure science and applied science; that is all nonsense. If applied science is taught in such a way that it is not pure science it is not science at all. If pure science is taught without reference to its application and without interest in its application it is not effective. So that the work of engineering research is one of the most important functions of a really comprehensive engineering school today. Our manufacturers are just beginning to realize that; they are beginning to come to the engineering schools for assistance. Some of them have research laboratories of their own. The research laboratory of the General Electric Company in Schenectady is fully as large as this building; and the men that they employ are not primarily engineers, they are primarily men of the highest possible scientific attainments, because they are the men who are best prepared to solve the problems. And their work goes beyond the immediate results, for while they are working always for some immediate object, in many cases they have to carry on research of a preparatory nature, to lay the foundation, the results of which are not immediately applicable. In that sense it is pure scientific research.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for November; *Lancaster, Pa.;* $4.00 per year, 50 cents a copy: "On the Quadrature of the Parabola," R. E. Moritz; "Geometrical Construction of the Roots of a Cubic, and Inscription of a Regular Heptagon in a Circle," C. B. Haldeman; "On the Summation of Certain Series," O. Schmiedel; "An Erroneous Rule for Finding a Hypotenuse with a Corollary," M. W. Jacobs.

National Geographic Magazine, for November; *Washington, D. C.;* $2.50 per year. "The Rise of the New Arab Nation," Frederick Simpich; "The Land of the Stalking Death," Melville Chater; "Where Slav and Mongol Meet," Maynard Owen Williams; "Syria: The Land Link of History's Chain," Maynard Owen Williams.

Popular Astronomy, for November; *Northfield, Minn.;* $3.50 *per year, 35 cents a copy:* "Twenty- Third Meeting of the American Astronomical Society," Continued; "The Occultation of Beta Capricorni, 1919 Nov. 27, as Visible in the United States," William F. Rigge; "Suspected Variable Star in the Trapezium of the Orion Nebula," J. A. Parkhurst; "Eratosthenes I, A Study for the Amateur," with Plates XLIV-XLVII, W. H. Pickering; "The Roman Calendar and its Reformation by Julius Caesar," Roscoe Lamont; "Design of a Stellar Photometer," G. A. Shook; "The International Astronomical Union," with Plate XLVIII, Joel Stebbins.

School Review, for November; *University of Chicago Press.* $1.50 *per year, 20 cents a copy:* "Present-day Needs in Higher Education," H. C. Morrison; "A Grading Standard," S. O. Rorem; "The Social Sciences in the University High School," Howard C. Hill.

Scientific Monthly, for November; *Garrison, N. Y.;* $5.00 *per year, 50 cents a copy:* "The Psychology of Daylight Saving," George T. W. Patrick; "The Snowfall of the United States," Robert DeC. Ward; "The Origins of Civilization," James H. Breasted; "The Meaning for Humanity of the Aerial Crossing of the Ocean," Dr. George De Bothezat; "Waiyautitsa of Zuni, New Mexico," Elsie C. Parsons; "The Controversy on the Origin of our Numerals," Florian Cajori; "Colloids and Living Phenomena," Dr. Nathan Fasten.

MORE INFORMATION CONCERNING OIL SHALE AT DILLON, MONTANA.

One of the few places where a plant has already been installed for the distillation of oil from shale is near Dillon, Montana. The shale at the site selected for the operations is a part of the phosphoria formation, which contains the beds of rock phosphate that are mined at several places near Bear Lake, in southeastern Idaho, for the manufacture of fertilizer. Phosphate beds are also associated with this shale in the vicinity of Dillon, and although they are neither so thick nor so rich as the beds in southeastern Idaho they have some prospective value. Soon after it became known that there was shale in the Dillon region from which oil could be distilled certain promoters began to organize companies to drill for oil in that region, and the search has been carried on persistently in spite of the fact that the geologic conditions there are almost wholly unfavorable to the occurrence of oil.

The character of these oil-shale beds was first brought to the attention of the public in a report by C. F. Bowen, published in 1918 as Bulletin 661 of the United States Geological Survey, Department of the Interior. A more detailed examination of these phosphatic shales and of beds of other formations that may contain oil shale was made late in 1918 by D. Dale Condit, whose report has just been published by the Survey as Bulletin 711–B, which is entitled *Oil Shale in Western Montana, Southeastern Idaho, and Adjacent Parts of Wyoming and Utah.* Copies of this report may be obtained on application to the Director of the United States Geological Survey at Washington, D. C.

MORE PEAT PLANTS AND A GOOD MARKET.

The total number of plants at which peat was commercially produced in 1918 was twenty-five, an increase of seven over the number operating in 1917. All the plants that operated in 1917, except four, contributed to the output in 1918, besides eleven that were not operating in 1917. The plants known to be operating in 1918 were distributed as follows: New York and New Jersey, 4 each; Massachusetts, 3; Georgia, Illinois, Indiana, and California, 2 each; Maine, New Hampshire, Connecticut, Pennsylvania, North Carolina, and Florida, 1 each. Nearly all the producers reported that the demand for peat exceeded the supply, and some stated that on account of limited facilities they were unable to fill the orders of their regular customers.

CHEMICAL PHYSIOLOGY.

By L. J. Henderson, *Harvard University.*

Great men of vision have known for a long time, say more than fifty years, that there is a science of general physiology which is the study of the fundamental activity of all living things, regardless of animals or plants, and that is largely a chemical matter that science is just beginning. The chemical department and the chemist of the country need help in the new development of biology. There is coming to be, in this way, some consolidation of all the sciences, and a larger and more important activity on the part of chemistry.

As a specific case of what chemistry may do, I would like to cite the example of Pasteur. It is not generally realized that Pasteur was a chemist and was never, all his life long, really a biologist. Men trained in his own school in Paris say as much. He never really learned to think biology, but he had the chemical training. He was primarily a chemical investigator, and he attacked practical problems and solved them. It happened to be the most important problem for human welfare.

There are situations growing out of chemistry, which are coming to underlie biology and they are going to be developed in every way. Chemistry is the thing that is of growing importance at this moment.

UNEXPLORED FIELDS IN CHEMISTRY.

By T. W. Richards, *Harvard University.*

We are only at the beginning of the understanding of the mechanism of chemical action. There are a great many things about it we do not know. We know oxide will combine with sodium and not with fluid. We may never find out why, but shall certainly find out more than we know at present. And it is the task primarily of the professors in the institutes of higher learning of the world to make these discoveries. Because of necessity, the interests of men who are working on the particular side of things, the application of those things which have already been discovered, are centered in other aspects of the subject. Fariday, when he made those experiments with waters and magnets which laid the basis of the dynamo, had no conception whatever of the power of the Niagara of previous years, and did not dream of it making such a rumpus. What he did was to discover the laws which determine electric induction. The same way in chemistry; it is a newer science than physics and has not got quite so far. It has not yet reached the highest state. Chemistry has things like that in the future. Chemistry holds the possibility of supplying energy, of continuing to build a scientific basis for medicine, not only pathological, but especially physiological.

BOOKS RECEIVED.

Co-related Mathematics for Junior Colleges, by Ernest R. Breslich, University High School, University of Chicago, pages xiii+301. 14×20 cm. Cloth. 1919. $1.25. University of Chicago Press, Chicago, Ill.

The Service of Everyday Life, by Edgar F. Van Buskirk, De Witt Clinton High School, and Edith L. Smith, Boston Normal School, pages xvi+416. 13.5×19.5 cm. Cloth. 1919. $1.40. Houghton M fflin Company, Chicago, Ill.

Danger Signals for Teachers, by A. E. Winship, Editor General Educator, Boston, pages xi+204. 13×19.5 cm. Cloth. 1919. $1.25. Forbes and Company, Chicago, Ill.

The Health of the Teacher, by Wm. E. Chancellor, pages 307. 13.5×19 cm. Cloth. 1919. $1.25. Forbes and Company, Chicago, Ill.

American Private Schools, an Annual Survey. Fifth edition, by Porter E. Sargent. 768 pages. 13×18.5 cm. Cloth. 1919. Porter E. Sargent, 14 Beacon Street, Boston.

Laboratory Directions and Study Questions in Inorganic Chemistry, by Alexander Silverman and Adelbert W. Harvey, University of Pittsburgh. Pages viii+102. 20×26.5 cm. Paper. 1919. $2.00 net. D. Van Nostrand Company, 25 Park Place, New York City.

BOOK REVIEWS.

Higher Arithmetic, by George Wentworth and David Eugene Smith. Pages v+250. 13×19 cm. 1919. Ginn and Company, Boston.

As this book is intended for teachers in training in normal schools and for pupils in high schools, special attention is given to the principles of the subject rather than to mechanical drill. The applications are such as have special signification to teachers and commercial students. The book is well planned for review purposes, uses a little practical algebra, and gives a brief explanation of the use of logarithms and the slide rule.

H. E. C.

The Service of Everyday Life, by Edgar F. Van Buskirk, De Witt Clinton High School, and Edith L. Smith, Normal School, Boston. Pages 15+416. 13.5×19.5 cm. Cloth. 1919. $1.40. Houghton, Mifflin Company, Chicago

This text is a marked change from the usual treatment of books of this nature. It is inspiring to get hold of one which is so splendidly written as to diction and facts. The subject matter has been treated under five major topics and each is thoroughly emphasized. The problems presented have been tested in class work and will be readily understood by pupils of high school age. There are over 200 half tones and drawings, splendidly selected, scattered throughout the book, to illustrate the subject matter treated therein. In many instances these cuts and drawings are entirely new. It is a book that deserves wide circulation. C. H. S.

Danger Signals for Teachers, by A. E. Winship, editor of "Journal of Education," Boston. Pages 14+190. 13×19.5 cm. Cloth. $1.25. 1919. Forbes and Company, Chicago.

When a person reads a book of which the author is well known to the reader, the amount of interest taken is always greater than in the case when the author is practically unknown. The author of this book, Dr. Winship, has been known to the teachers of the United States through his magazine, *Journal of Education* for a third of a century, and he is

National American Speech Week Has Been Recently Celebrated by American School Teachers

No one can be taught American ideals so well as through the mother tongue. No one can be taught the principles of American government so thoroughly as through the English language. No one changes from a "hyphenated" American into a real American so quickly as the man who learns the English language.

One phase of the movement of particular interest is the fact, as shown in a "Guide to American Speech Week," published by the National Council of Teachers of English, that early in the work the need of a standard of pronunciation was felt. The Chicago Woman's Club, therefore, of its own initiative sent out a questionnaire to eighteen schools of high and normal grade, to seven schools of dramatic art, to twenty-two universities (including all the prominent colleges from Harvard, Yale, and Columbia in the East to Leland Stanford Junior in the West). As a result of this questionnaire, the Chairman of the Committee has published the following statement:

"The high schools have been so slow in answering that no decision can be reported from their group; the dramatic schools differ so widely that their opinion becomes suggestive rather than authoritative; the college report alone may be considered a consensus of opinion. The preference here narrows down to two—Webster's New International Dictionary, published by G. & C. Merriam Company, and Murray's New English Dictionary (unfinished) published in Oxford, England. As the advocates of Murray admit that the size and cost make it prohibitive for the ordinary individual, even they concede that the best general one-volume dictionary is Webster's New International."

Evidently the New International will play a prominent part in the Speech Movement. Are you so fortunate as to have a copy of this "Supreme Authority" in your school?

thoroughly familiar with the subject upon which he writes. The advice given is of the most common sense kind. There is value in every page. It tells the teacher just how to act and conduct himself both in and out side of the school room. The book is written not only for the present day but for the future. The author points out the way and means by which the teacher may secure success in his line of work. No person in any way associated with the teaching profession should neglect to read this timely book.

There are five divisions and it is as interesting to read as a first class novel and at the same time is full of most valuable information.

C. H. S.

Researches in Physical Optics, by R. W. Wood, John Hopkins University. Pages xiii+184+10 plates. 20×25 cm. Paper. 1919. University of Columbia Press, New York City.

This volume is one of the results coming from the use of a memorial fund given to Columbia University by Ernest Kingston Adams for physical research. It is a most valuable contribution in physical science in the direction of Resonance Radiation and Resonance Spectra.

No one is more competent to investigate these subjects than the author. The line of investigation is new and beyond a shadow of a doubt authentic and accurate. Investigations were made in collaboration with M. Kimura, W. P. Speas, G. Ribaud, G. A. Hemsalech, C. F. Meyer, L. Dunoyer, and F. L. Mohler. It is a volume with which every college and University physicist should be familiar. C. H. S.

Vocational Civics, by Frederic M. Giles, De Kalb, Ill., High School, and Imogene K. Giles, J. Sterling Morton High, Cicero, Ill. Pages x+252. 13.5×19 cm. Cloth. 1919. $1.30. The Macmillan Company, New York City.

The need for vocational guidance for girls and boys in our country has wonderfully increased during the last five years, ever since the war started in 1914. This has been especially true during the last two and one-half years or during the time the United States was drawn into the war. The resources of our country were drained as never before in history. Many young people especially, had their faculties tested in ways which brought out their latent abilities. This has shown educators that it is absolutely essential for boys and girls of our country to be educated not only in books but they must be able and trained vocationally so that when the strain or stress is brought on they will be able to jump into the work with a good understanding.

This book makes splendid reading not only for teachers but for the intelligent layman. It is splendidly written, the diction is fine and the statements are true. There are nine chapters and at the end of the seventh there is a list of pertinent questions as well as a selected bibliography. Throughout the book are scattered many half tones. Mechanically this book is very well made. C. H. S.

Theory of Evolution, by Wm. B. Scott, Princeton University. Pages xi+183. 13.5×19.5 cm. Cloth. $1.00. 1919. Macmillan Co., New York City.

This text is a compilation of six Westbrook lectures delivered by the author, on the theory and general state of evolution. There are many people who believe that the theory of evolution is an outgrown one, but to the great number of biologists it is a real new theory. The author explains in an interesting manner and to the student understanding the theory he will undoubtedly agree with practically everything the author has written. There is a splendid introduction of eleven pages and this is a text that every biologist should read and study. C. H. S.

Committee on Education and Special Training, a review of its work during 1918, by the Advisory Board. Pages 144. 20.5×26.5 cm. Paper. 1919. War Department, Washington.

To all people who are interested in the special training to which thousands of our boys were subjected during the recent war, this report will be of intense interest. It is prepared under the direction of Dr. Charles W. Mann, that prince of investigators and splendid scholar. The first thirty-four pages are devoted to the full and complete history of the organization of the Advisory Board of which Dr. Mann is Chairman.

Part II deals with the military administration and is arranged in a most careful manner.

Part III is devoted to the business management of the various enterprises that come in touch with this committee. There are several appendices and also a list of the colleges and high schools in which this special training was organized.

There are many half tones scattered through the volume. It is a splendid account of this particular department of our Government work.

C. H. S.

Health of the Teacher, by W. E. Chancellor. Pages ix+307. 13.5×19.5 cm. Cloth. 1919. $1.25. Forbes Company, 443 South Dearborn St., Chicago.

There are many teachers who do not seem to think that their health has very much to do with their efficiency as instructor of the youth. There is not any question but if many teachers would take better care of their bodies the quality of their work would be very much higher than it is at present.

The book is an outgrowth of many years of study of physical hygiene and medical training, followed by long educational experience. The book is one which all teachers should possess and read, as it will not only assist them in maintaining health, but through the knowledge of the content of the book they will be able to cause their pupils to feel the influence that the knowledge of the book will convey.

There are two parts, part one containing nineteen chapters and part two which also contains nineteen chapters. The entire subject of one's health is thoroughly treated. It is an interesting book to read. There are five pages devoted to a complete index. C. H. S.

Thrift and Conservation, How to Teach It, by Art. H. Chamberlain and James F. Champion. Pages 272. 12.5x19.5 cm. Cloth. 1919. $1.40 net. J. P. Lippincott Co., Philadelphia, Pa.

This is such a splendid book that the reviewer hardly knows where to begin. It is a volume that should be read by every man, woman, boy and girl in the country. Not only read but studied in order that the scales may fall from our eyes, so that we may see wherein we are so sinfully wasteful in this country of ours. We are thrifty people, but we would be much more so if we were not so wasteful. The idea of saving was brought home to us somewhat during the last months of the war yet our people seem to have forgotten it. The book shows the way it is possible in almost every phase of life to be thrifty and exploits the idea of conservation of mind and material in our daily labors. It bears down especially heavy on thrift in clothing, the saving of paper, of time and money, and other things that make up our daily life.

There are twenty-four chapters and a few illustrations. It is printed on uncalendered paper, thus removing the glare, which makes the book optically easy to read. It is a book that would be interesting for one with ordinary knowledge to read. Many of the chapters terminate with suggestive topics for discussion and references for a further study. It should certainly have a wide circulation. C. H. S.

VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE MODEL 3

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.

Spencer Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant.
Price, $150.00

SPENCER BUFFALO U.S.A.

SPENCER LENS COMPANY

Buffalo, New York

Manufacturers of **Microscopes, Microtomes, Delineascopes, Optical Glass, Scientific Apparatus, Etc.**

SPENCER BUFFALO U.S.A.

Kalato Laboratory Filter Paper

Suitable for all analytical purposes other than those requiring the use of a paper extracted with Hydrochloric and Hydrofluoric acid. Filters rapidly and retains the finest precipitates. Weight of ash 3 in. circle, 0.012 gm. Sample sent on request.

Complete Supplies for Chemistry, Biology and Physics

Let us quote prices on your next list of requirements

THE KAUFFMAN - LATTIMER CO.

44-46 East Chestnut Street

COLUMBUS, OHIO

Food Saving and Sharing, by United States Food Administration. Pages x+102. 13x20 cm. Board. 1919. Doubleday, Page & Co., New York City.

This is a little book which has been prepared under the authority of the Treasury Department for the purpose of exploiting the idea of "Food Saving and Sharing." It is written primarily for use in schools and the style is plain enough for youngsters to understand if put into their hands. At the same time it will act as a guide to the teachers in shaping her courses in these subjects. C. H. S.

Textiles and Clothing, by Ellen B. McGowan, Teachers College, Columbus University, and Charlotte A. Waite, Julia Richman High, New York City. Pages 268. 13x19 c. m. Cloth. 1919. The Macmillian Co., New York City.

This book has been prepared primarily to fill the need that has arisen comparatively recently by the introduction of the study of textiles into our high school courses. It is presented in a manner sufficiently simple that the understanding may be grasped by the average high school pupil. The book emphasizes more pointedly the finished product and its relation to the household, and the use to girls who are pursuing this subject.

There are ten chapters, each furnished with a list of various kinds of cloth, etc., mentioned in the chapter. There is a bibliography appended as well as a glossary of terms used. A splendid index is also included. The book deserves wide circulation. C. H. S.

The Realities of Modern Science, by John Mills, Western Electric Laboratories. Pages xi+327. 14x20.5 cm. Cloth. 1919. $2. The Macmillan Co., New York City.

This volume is intended primarily for the general reader who is interested in the advancement of science and yet has not the time himself to devote to personal investigations. It is a book that is splendidly written and put together in an understandable way. The average layman will have no difficulty in understanding it if he is interested in science, mathematics having been almost entirely eliminated. The author has given a wonderful report of the advance of science during the last two decades. The presentation of the "Brownian Movement" is one of the most skillful and clear methods that the writer has ever seen.

There are twenty-two chapters and a most complete index. It is a book that a busy man, with scientific inclinations, should get and study. The knowledge therein gained will give a good working understanding of the recent advancement of science. C. H. S.

CLAY MINING FEATURES OF THE YEAR.

The outstanding feature of the clay-mining industry in 1918, besides the considerable general decrease in output and the increase in price, was the large decrease in the output of the clays that enter into the manufacture of the highest grades of ware in spite of strong demand and high prices. These clays are produced principally in the South, and the decrease in their production was caused largely by the scarcity of labor and fuel and the difficulties of transportation. It was almost impossible to get shipments through to the North, where the principal market for these clays is found.

GOLD AND PLATINUM PLACERS IN THE KIWALIK-KOYUK REGION.

The search for the sources of the placer gold found in the streams of Alaska has been a part of the work of the geologists who have been studying and mapping the topography and geology of the Territory. A report by G. L. Harrington on the gold and platinum placers of the region near the Kiwalik and Koyuk rivers forms a part of the Geological Survey's Bulletin 692–G. Mr. Harrington describes the geology and mineral resources of the region, stating the means of communication, timber, coal, and sources of water supply, gives detailed descriptions of the placers, and makes suggestions as to the original sources of the metals.

The best way to secure creative and inspirational ability in Science and Mathematics Teaching is to be familiar with the methods adopted by the leaders in this work as shown by their articles in the pages of this Journal.

CONTENTS *for* DECEMBER, 1919

No Numbers Published for
JULY, AUGUST AND SEPTEMBER

School Science and Mathematics

Member of the Educational Press Association of America

No Numbers Published for JULY, AUGUST and SEPTEMBER.

PRICE. The subscription price is Two Dollars and Fifty Cents a year, if paid in advance; single copies 30 cents.

ALL REMITTANCES should be made payable to the order of **School Science and Mathematics. Remittances should be made by Post Office Money Order, Express Order, or Bank Draft.** If personal checks are sent, please add ten cents for collection.

SCHOOL SCIENCE AND MATHEMATICS is the "official organ" of the following associations: The Central Association of Science and Mathematics Teachers, Eastern Association of Physics Teachers, The Physics Club of New York, Missouri Society of Teachers of Mathematics and Science, Science and Mathematics Section of the Oregon State Teachers Association, Saskatchewan Science and Mathematics Teachers Association, Southern Pacific Science and Mathematics Teachers Association, Kansas Association of Mathematics Teachers New York State Science Teachers Association, New Jersey Science Teachers Association.

POSTAGE IS PREPAID for all subscriptions in the United States and Mexico. For Canada add 25 cents for postage. For all other countries in the Postal Union, add 50 cents.

CHANGE OF ADDRESS. Subscribers should send notice of any change of address before the 12th of each month; otherwise they are held responsible for magazine, sent to their former address, and no duplicate copies will be sent except on payment of 30 cents for each copy. Send notices to School Science and Mathematics, Mount Morris, Ill., or 2059 East 72nd Place, Chicago.

MANUSCRIPTS. Contributions on Science and Mathematics Teaching are invited. Articles must be written on one side of the sheet only. All illustrations must be drawn or written in jet black on a separate sheet of manuscript. Contributors are requested to write scientific and proper names with particular care. Manuscripts should be sent to the Editor of **School Science and Mathematics, 5517 Cornell Ave., Chicago,** or to the proper departmental Editor. Books and pamphlets for review should be sent to the Editor. To insure insertion in any number, manuscript must be in the editor's *possession not later than the 20th of the second month before* publication.

MISSING NUMBERS will be replaced *free* only when claim is made within thirty days after receipt of the number following.

REPRINTS, if desired, must be ordered in advance of publication. Reprints of leading articles will be printed as ordered, the actual cost (with cover, if desired) to be paid for by the author. Reprints *must* be *paid* for when ordered. The table below shows the *approximate* cost of reprints consisting of plain text or text with line engravings. The actual cost may vary from the figures given and will depend upon the amount of work in re-making the pages into forms, press work, paper, printing, etc.

Number of Copies	100	Extra Hundreds	Number of Copies	100	Extra Hundreds
2 pages	**$1.25**	**$0.20**	**16 pages**	**$5.40**	**$0.85**
4 pages	**1.70**	**.35**	**20 pages**	**7.20**	**1.25**
8 pages	**3.50**	**.65**	**Cover, extra**	**2.25**	**.35**
12 pages	**4.90**	**.95**			

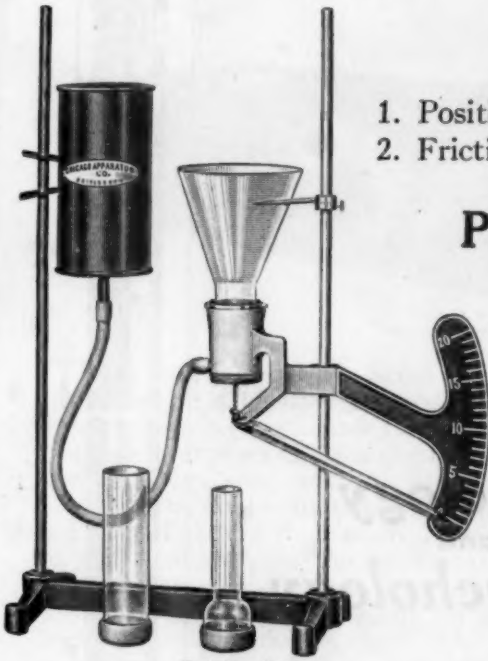
SCHOOL SCIENCE AND MATHEMATICS

PUBLICATION OFFICE **MOUNT MORRIS, ILLINOIS**

Business Office, 2059 72nd Place, Chicago.
Editorial Office, 5517 Cornell Ave., Chicago.

Demonstrates More Effectively

—more Clearly and more Accurately—that "the downward pressure in a liquid is independent of the shape of the vessel" than any other form of this apparatus.



Cat. No. 1062

Why?

1. Positive Acting Diaphragm
2. Frictionless Indicating Device

Pascals Vases

Improved Form

consists of three glass vessels, each of different shape, 15 cm. high, with rubber gaskets, to be fastened in metal base supported on a stand. The pressure is exerted on a rubber diaphragm the movements of which are multiplied by a lever 21 cm. long. The indications on the scale, 20 cm. long and graduated from 0 to 20, may be clearly seen across the largest class room. The water supply tank, one liter capacity, may be quickly and easily adjusted to any desired height. It permits of easy and rapid filling and emptying of the vases without any spilling of water. This new model yields better and more satisfactory results than any other form of this apparatus because the type of diaphragm and indicator employed is positive in its action and free from friction. Complete as illustrated..........$15.00

Try This Apparatus in Your Laboratory and Note the Result

CHICAGO APPARATUS COMPANY

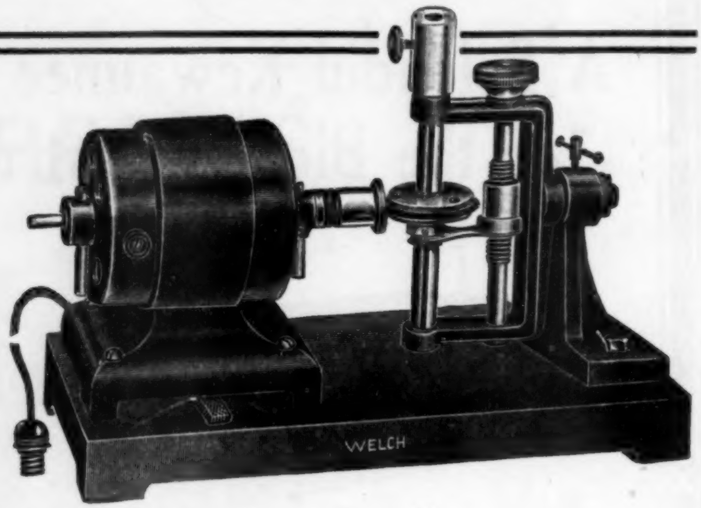
Physical, Chemical, Biological, Agricultural Apparatus

32 South Clinton St. — Chicago, Ill.

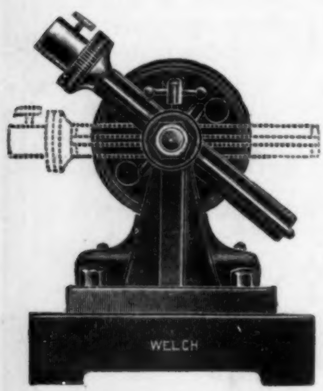

C.H. STOELTING Co CHICAGO, U.S.A.

A Sign of Quality **QUALITY WELCH SERVICE** from a House of Service

Another **WELCH** *Specialty*



No. 905. UNIVERSAL MOTOR ROTATOR. This rotator has been designed especially for school and laboratory use. The motor will run on either A. C. or D. C. of 110 volts. The speed may be varied from a few revolutions per minute to 1500 R. P. M. The speed changes are continuous—not in steps—and speed is changed by simply turning a thumb screw. The holder for the accessories is standard form and size and will hold all commonly used accessories. A chuck is included with the instrument for holding discs, etc. The position of the rotating shaft may be made horizontal, vertical or any intermediary position, and may be held firmly in any of the positions. The use of the friction disc eliminates all jerkiness of starting and running. The motor is especially adapted for this purpose and is very powerful and will pull any accessory at full speed. A stop is provided so that excessive speeds are not possible although sufficient speed is provided for to operate all rotator accessories. A speed counter is mounted so that the R. P. M. may be determined where quantitative work is required. The entire apparatus is about 30 cm. long, 15 cm. wide and 20 cm. high. Handsomely finished in black enamel and nickel plated trimmings. Complete as described with 6 feet of cord and detachable plug for connection. Write for further information and price.



W. M. Welch Scientific Company

Manufacturers, Importers and Exporters of Scientific Apparatus

1516 Orleans Street **Chicago, Ill., U. S. A.**

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	**$1.00**
School Science, Vol. I, eight numbers	**6.00**
School Science, Vols. II and III, each	**6.00**
School Science, Vol. IV, three numbers	**.75**
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	**2.00**
School Science and Mathematics, Vol. XVIII	**2.50**